Changes in the Aquatic Plant Community of Round Lake

Chippewa County, Wisconsin 1988-2004

submitted
May 2006

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West Central Region
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EXECUTIVE SUMMARY

Round Lake is a shallow soft-water, mesotrophic, seepage lake with fair water clarity and quality.

The plant community colonized almost three-quarters of the littoral zone to a maximum depth of 12 feet, most abundant along the west and south bog fringes. Ten of the 48 aquatic plant species in Round Lake are designated as rare species of Special Concern. In 2004, *Nymphaea odorata* was the dominant species and *Brasenia schreberi* was sub-dominant, both exhibiting a growth form of above average density in Round Lake. The aquatic plant community is characterized by above average quality, excellent species diversity of soft water, bog species, high sensitivity to disturbance and an extreme closeness to an undisturbed condition.

There has been significant change in the aquatic plant community in Round Lake during 1988-2004 (Coefficients of Community Similarity). The appearance and increased dominance of *Myriophyllum heterophyllum* in 1990, the appearance of filamentous algae in 1997, a complete switch of dominant and sub-dominant species between 2000 and 2004 and an increased occurrence of floating-leaf and emergent plant species that provide valuable habitat are some of the major changes.

A healthy aquatic plant community plays a vital role within the lake community. Plants provide improved water quality and valuable resources for fish and wildlife. Lakes with a healthy and diverse community of native aquatic plants are more resistant to invasions of non-native species and excessive growth of more tolerant species.

Management Recommendations

1) Township maintains the slow, no-wake zone. Changes in the aquatic plant community suggest that this zone is protecting and maintaining the health of the aquatic plant community.
2) Residents protect and restore natural vegetation buffer at the shore. Comparison of the plant community at natural versus developed shorelines indicate that the aquatic plant community has been impacted at developed sites and that the natural shoreline sites support a plant community that is more valuable for habitat and water quality protection.
3) Residents maintain lakeshore property septic systems.
4) Residents and Department maintain protection of the Sensitive Areas designated in 2003.
5) All lake users protect the aquatic plant community in Round Lake. Having a sensitive plant community suggests that Round Lake has been subjected to fewer disturbances, but also means that it could be most damaged by increased disturbance.
6) Lake residents become involved in the Self-Help Volunteer Lake Monitoring Program.

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Round Lake, Chippewa County
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I. INTRODUCTION

Studies of the aquatic plants (macrophytes) in Round Lake were conducted August 1988, August 1991, July 1994, August 1997, July 2000 and July 2004 by Water Resources staff of the West-Central Region of the Department of Natural Resources (DNR). The surveys are conducted as part of a Long Term Trend Study involving lakes throughout the state. Aquatic plant data is collected every three years and water quality data is collected every year on these trend lakes.

Long term studies of the diversity, density, and distribution of aquatic plants will provide information that will be valuable for decisions about fish habitat improvements, designation of sensitive wildlife areas, water quality improvement, and aquatic plant management. Trend data can reveal changes occurring in the aquatic plant community and the lake ecosystem.

A study of the diversity, density, and distribution of aquatic plants is an essential component of understanding a lake ecosystem due to the important ecological role of aquatic vegetation in the lake and the ability of the vegetation to characterize the water quality (Dennison et al. 1993).

Ecological Role: All other life in the lake depends on the plant life - the beginning of the food chain. Aquatic plants and algae provide food and oxygen for fish, wildlife, and the invertebrates that in turn provide food for other organisms. Plants provide habitat, improve water quality, protect shorelines and lake bottoms, add to the aesthetic quality of the lake and impact recreation.

Characterize Water Quality: Aquatic plants serve as indicators of water quality because of their sensitivity to water quality parameters, such as water clarity, mineral content and nutrient levels (Dennison et. al. 1993).

Background

Round Lake is a 216-acre seepage lake in northern Chippewa County with a maximum depth of 18 feet and mean depth of 10 feet. It is a shallow soft water lake with bog wetland fringe along the west and south shorelines. There is an intermittent outlet to McCann Creek.

Round Lake has a public boat access at the county park on the northeast shore. Fishing, swimming, and wildlife watching are important recreational uses of the lake.

The watershed of Round Lake is one-square mile. The ratio of watershed to lake is approximately 3:1. This relatively small watershed would not likely be a major impact to water quality in Round Lake. Additionally, much of the watershed is protected by naturally vegetated land cover.

Forest and savanna protect one-half of the Round Lake watershed (Table 1) and land use with some type of permanent vegetation cover protects 92% of the watershed. Cropland would contribute the greatest amount of nutrients (phosphorus) per acres, but has virtually disappeared from the watershed since 1938 (Table 1).

Table 1. Land Use within the Round Lake Watershed, 2000

		Acres		% Land Use	Pounds of Phosphorus	
		1938	2000	2000	Input/acre/yr	Current Load
Forest/ Savanna		192	248	50.9%	0.080	20
Grassland/ Hayfields		71	58	11.9%	0.268	16
Wetlands		190	141	29.0%	0.089	13
Development	Moderate Density		26	5.3%	0.446	12
	Low Density	13	9	1.8%	0.089	1
Roads		3	5	1.0%	0.446	2
Cropland		19		0.0%	1.340	0
Total		488	487	100.0%		63

History

A paleoecological study of sediment cores conducted in 1995 indicated that Round Lake was, at one time, a bog that had a much lower water level than currently (Garrison 2000).

The sediment cores also provided clues to the history of the watershed impacts. Increased sedimentation occurred in the late 1800's, during the logging era; another short-term, but significant increase in sedimentation and nutrient load during the 1920's, coinciding with early cottage development. Aquatic plant growth increased at that time also and an algae bloom occurred in the 1930's. After the initial development phase, sedimentation declined to near pre-settlement levels.

Soil erosion and nutrient inputs again began increasing in the 1970's and 1980's with a surge of new development and the conversion of cottages to year-round homes. This construction resulted in an increase in hard surfaces, an increase in cultivated lawns and a decrease in native vegetation. The sedimentation and nutrient load has remained at levels above pre-settlement conditions since that time.

In 1990, a volunteer lake monitor, Julius Derge, reported the appearance of an aquatic plant that he had not been recorded in Round Lake before. He reported that it seemed to have become denser than the other aquatic plant species and was producing many fragments that were washing onto the shoreline. Other lake residents believed that the appearance of this plant coincided with an increase in boat traffic on Round Lake. This species, *Myriophyllum heterophyllum,* was not found during the 1988 plant survey, but became one on the dominant species by 1991. *M. heterophyllum* can readily spread by plant fragments.

A boating impact study was conducted on Round Lake during the summer of 1994. Water sampling before and after high boating-use weekends showed a sharp decrease in water clarity and a sharp increase in water column phosphorus during the weekends (Asplund 1997).

Research on the mixing depths of boat motors have shown that a 50 hp motor will mix and resuspend sediment to a depth of 15 ft. (Wagner 1990). With a maximum depth of only 18 ft., approximately 75% of Round Lake would be susceptible to impacts by a 50 hp motor. In addition, more than 25% of Round Lake is shallow enough to be impacted directly by propellers and hulls.

In 1996, a no-wake zone was designated and marked by buoys along the west shoreline. This no-wake zone was designed to serve several purposes:

1) reduce sediment resuspension and sediment phosphorus release by boat traffic in the zone with less than 10 feet of water depth
2) curb the spread by plant fragments created by boat motors of more aggressive plant species such as *Myriophyllum hererophyllum*
3) protect nesting loons along the bog fringes
4) provide a refuge for recreaters not participating in wake-producing activities

In 2000, New Auburn High School Adopt-a-Lake program conducted an opinion survey at the boat landing and compared the results to the 1998 opinion survey of Round Lake Association members (Table 2).

Table 2. Opinion Survey of Round Lake, 1998-2000.

Question		2000-Landing Survey	1998 Resident Survey
How lake is used	Fishing/Hunting	42%	12%
	Non-motorized Use	28%	26%
	Peace and Quiet	12%	25%
	Motorized Use	10%	25%
	Natural Beauty	8%	25%
Fishing	Good	58%	43%
	Fair	18%	23%
	Poor	24%	34%
Slow-no-Wake Buoys	Observed	74%	26%
Support of Slow-No-Wake	Entire Lake	48%	50%
	¾ of Lake	70%	
	½ of Lake	75%	
Recreational Enjoyment is Very Good		90%	50%

In 2000, several residents reported a floating mat of what appeared to be sewage that contained cigarette butts. There was a rumor that a resident having trouble with his septic may have released septic contents into the lake.

In 2003, a Sensitive Area Designation Study was conducted on Round Lake. The areas that were designated are the areas of the lake that are most important for providing habitat for fish and wildlife and protecting water quality (Appendix XXI). These sites have additional protections to maintain the habitat and water quality features in the lake (Konkel 2004).

Sensitive Area Recommendations

1) Maintain shoreline vegetation and aquatic vegetation in an undisturbed condition for wildlife habitat and corridor, fish habitat and cover and as a nutrient buffer for water quality protection.
2) Minimize removal of any shoreline or aquatic vegetation
3) Maintain snag trees to provide wildlife habitat.
4) Protect the emergent vegetation as an erosion buffer.
5) Do not remove fallen trees along shoreline.
6) No alteration of the littoral zone except for improvement of spawning sites
7) Restrict and limit pier placement, bank grading, recreational floating devices (permit required)
8) No permit approval for boat ramps, sand blankets, pea gravel beds, dredging, retaining walls, or filling.
9) Restrict bank stabilization to biological methods
10) Maintain no-wake zone to protect vegetation and protect the sediments from suspension.
11) Post “Loon Alert” signs.
12) Restore shrubs and herbaceous plant cover on the old road right-of-way.

II. METHODS

Field Methods

The same study design was used for the 1988, 1991, 1994, 1997, 2000 and 2004 aquatic plant surveys and was based on the rake-sampling method developed by Jessen and Lound (1962). Twenty-three equal-distance transect lines were placed perpendicular to the shoreline with the first transect being randomly placed. These transects were mapped and used for all subsequent surveys (Appendix XIX).

One sampling site was randomly located in each depth zone (0-1.5 ft., 1.5-5 ft., 5-10 ft., and 10-18 ft.) along each transect. Using a long-handled steel-thatching rake, four rake samples were taken at each sampling site, one from each quarter of a 6-foot square quadrat. The aquatic plant species that were present on each rake sample were recorded. The species recorded include aquatic vascular plants and macrophytic algae (having morphologies similar to vascular plants), such as muskgrass and nitella. The presence of filamentous algae was also noted. Each species was given a density rating (0-5) based on the number of rake samples on which it was present, at each sampling site.

a rating of 1 indicates that a species was present on one rake sample at that site
a rating of 2 indicates that it was present on two rake samples
a rating of 3 indicates that it was present on three rake samples
a rating of 4 indicates that it was present on all four rake samples
a rating of 5 indicates that it was present abundantly on all four rake samples at that sampling site.

Specimens of each plant species found were collected and saved in a cooler for later preparation of voucher specimens. Nomenclature was according to Gleason and Cronquist (1991). Visual inspection and periodic samples were taken between transect lines in order to record the presence of any species that did not occur at the sampling sites. The actual depth and sediment type at each sampling site was recorded.

The type of shoreline cover was recorded at each transect. A section of shoreline, 50 feet on either side of the transect intercept with the shore and 30 feet back from the shore, was evaluated. The percentage of each cover type within this 100' x 30' rectangle was recorded.

Data Analysis

The data for each year was analyzed separately and compared. The percent frequency of occurrence of each species was calculated (number of sampling sites at which it occurred/total number of sampling sites) (Appendices I-VI). Relative frequency was calculated (number of sampling sites at which it occurred/sum of all species occurrences) (Appendices I-VI). The mean density was calculated for each species (sum of a species' density ratings/number of sampling sites)(Appendices VII-XII). Relative density was calculated (sum of a species' density ratings/sum of all plant densities)(Appendices VII-XII). A “mean density where present” was calculated for each species (sum of a species' density ratings/number of sampling sites at which it occurred)(Appendices VII-XII). The relative frequency and relative density were summed to obtain a Dominance Value for each species (Appendices XIII-XVIII).

Simpson's Diversity Indices were calculated for each sampling year $1-(\sum(\text{Relative Frequency}^2))$ (Appendices I-VI). Each sampling year was compared by a Coefficient of Community Similarity.

An Aquatic Macrophyte Community Index (AMCI), developed for Wisconsin lakes, was applied to Round Lake. Data in seven categories that characterize the aquatic plant community is converted to values 0 - 10 as outlined by Nichols et. al. (2000). The Average Coefficient of Conservatism and Floristic Quality Index measure disturbance in the community (Nichols 1998). A Coefficient of Conservatism is an assigned value, 0-10, the probability that a species will occur in a relatively undisturbed habitat. The Average Coefficient of Conservatism is the mean of the coefficients for all species found in a lake.

Floristic Quality Index, calculated from the Average Coefficient.

III. RESULTS

PHYSICAL DATA

Water Chemistry

Many physical parameters impact the aquatic plant community. Water quality (nutrients, algae, water clarity and water hardness) influence the plant community as the plant community can in turn modify these parameters. Lake morphology, sediment composition and shoreline use also impact the aquatic plant community.

WATER QUALITY - The trophic state of a lake is a classification of its water quality. Phosphorus concentration, chlorophyll concentration and water clarity data are combined to determine the trophic state.

Oligotrophic lakes are low in nutrients and biomass and support smaller populations of fish.

Eutrophic lakes are high in nutrients and biomass and experience frequent algal blooms.

Mesotrophic lakes are intermediate in nutrient levels and biomass.

Phosphorus is a limiting nutrient in many Wisconsin Lakes so is measured as an indication of nutrient enrichment.

2004 Mean Summer phosphorus in Round Lake was 24ug/l.
This concentration of phosphorus is in the mesotrophic range (Table 3).

Table 3. Trophic Status

	Quality Index	Phosphorus ug/l	Chlorophyll ug/l	Secchi Disc ft.
Oligotrophic	Excellent	<1	<1	>19
	Very Good	1-10	1-5	8-19
Mesotrophic	Good	**10-30**	5-10	**6-8**
	Fair	30-50	10-15	5-6
Eutrophic	Poor	50-150	**15-30**	3-4
Hypereutrophic	Very Poor	>150	>30	>3
Round Lake 2004 Summer Mean	**Fair**	**24**	**16.6**	**6.07**

After Lillie & Mason (1983) & Shaw et. al. (1993)

The mean summer phosphorus concentration in Round Lake have remained in the mesotrophic range during the years that the lake has been sampled (Figure 1). The mean phosphorus levels in 1999-2001 were the lowest recorded since sampling began in 1986, but increased substantially in 2002-2004.

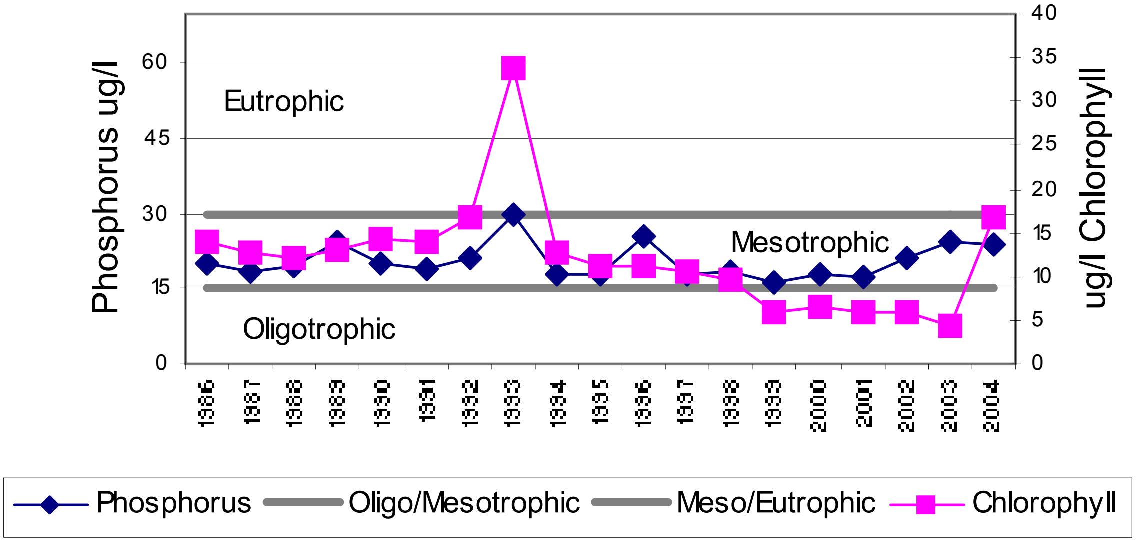

Figure 1. Mean summer phosphorus and chlorophyll concentration in Round Lake, 1986-2004.

Algae are natural and essential in lake ecosystems, but high populations of algae can increase turbidity and lower light availability for plant growth.
2004 mean summer chlorophyll in Round Lake was 16.6ug/l.
This is in the eutrophic range for algae (Table 3).

The 1986-2004 mean summer chlorophyll concentration in Round Lake has varied within the mesotrophic/eutrophic range (Figure 1). There was an extreme and unusual algal bloom of unknown cause in 1993; the lowest chlorophyll values (in the oligotrophic range) were recorded were during 1999-2003; chlorophyll increased dramatically in 2004 (Figure 1).

Filamentous algae had not been recorded at the sample sites during 1988-1994, but was recorded at:
22% of the sample sites in 1997
7% of the sample sites in 2000
4% of the sample sites in 2004

Filamentous algae was commonly occurring over the entire littoral zone in 1997, but only common in the 0-1.5ft depth zone in 2000 and not common at all in 2004 (Figure 2).

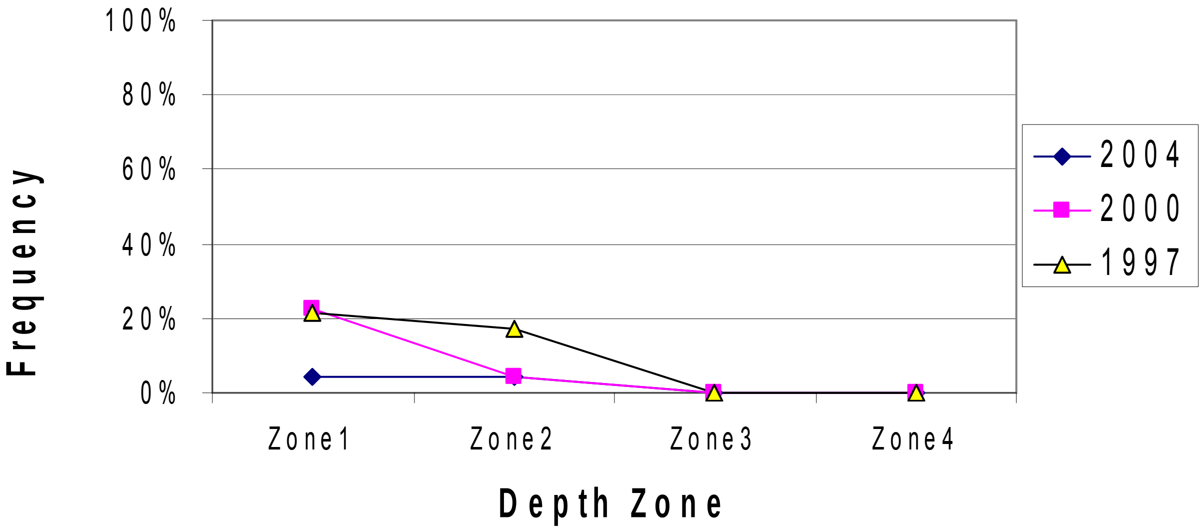

Figure 2. Frequency of occurrence of filamentous algae in Round Lake, by depth zone 1997-2004

Water clarity is impacted by a combination of water color (due to dissolved organic chemicals such as naturally occurring tannins) and turbidity (caused by suspended materials such as silt and/or algae). Water clarity is measured with a Secchi Disc, which measures the combined impacts of color and turbidity.

2004 Mean summer water clarity in Round Lake was 6.07 feet.

This is in the mesotrophic range for clarity (Table 3).

Mean summer water clarity during 1986-2004 in Round Lake has varied within the mesotrophic/eutrophic range during the study period (Figure 3). The extreme algae bloom in 1993 is verified by the lowest recorded water clarity in the same year. In 1995-97, Round Lake experienced the best clarity recorded, but declined since 1997 to fair water clarity in 2004 (Figure 3).

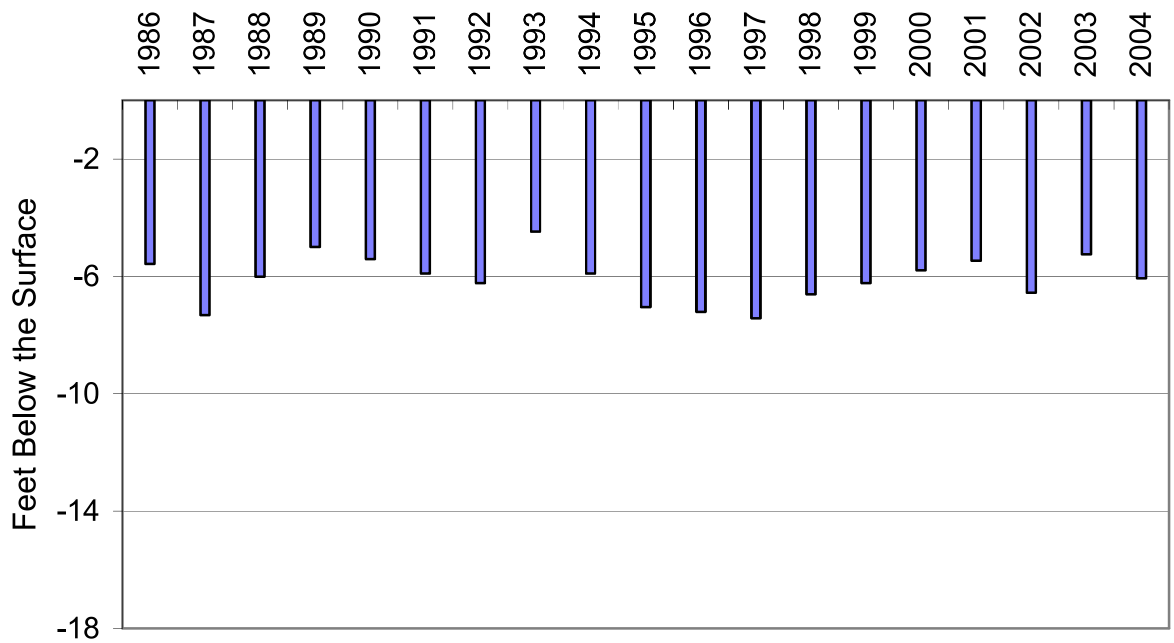

Figure 3. Mean Summer Water Clarity in Round Lake, 1986-2004.

Based on the combination of the phosphorus and algae concentrations and water clarity data, Round Lake is a mesotrophic lake with fair water quality (Table 3). In this trophic state, moderately abundant plant growth and periodic algal blooms would be expected.

The 1988-2004 alkalinity and hardness levels, as measured by the amount of calcium carbonate, varied between 4-8 CaCo3 mg/l in Round Lake. Hardness levels in the range of 0-60 CaCO3 mg/l are indicative of soft water; soft water lakes tend to have less plant growth.

Lake Morphometry

The morphometry of a lake is an important factor in analyzing the distribution of aquatic plants. Duarte and Kalff (1986) found that the slope of the littoral zone accounted for 72% of the observed variability in the growth of submergent vegetation. Gentle slopes provide more stable rooting conditions and a broader zone of potential plant growth than steep slopes (Engel 1985).

Round Lake has a relatively shallow, rectangular basin. A large portion of the littoral zone is gradually sloped and therefore favorable to plant growth.

Sediment Composition

Silt was the dominant sediment overall in Round Lake (Table 4) (Figure 4), but found only at depths greater than 5 feet.

Peat sediments which are loosely consolidated, have a low specific gravity and are therefore flocculent were dominant in the 0-1.5ft-depth zone, declining with increasing depth. Peat did not occur along the east shoreline.

Silt/peat mixtures were dominant in the 5-10ft depth zone (Table 4).

Sand was dominant in the 1.5-5 ft depth zone, occurring primarily as a band of firm sediment along the east and west shorelines. Sand mixed with gravel or rock was common in the shallow depth zone.

Table 4. Sediment Composition in Round Lake, 2004

		0.1.5 ft	1.5-5ft	5-10ft	10-20 ft	Overall
Soft Sediments	**Silt**			22%	80%	20%
	Silt/Peat		4%	35%	13%	13%
	Peat	30%	17%	13%		17%
Mixed Sediments	**Sand/silt**		4%	17%		6%
	Sand/Peat	4%	17%			6%
Hard Sediments	**Sand**	9%	42%	9%	7%	18%
	Sand/Gravel	22%	9%			8%
	Sand/Rock	22%				6%
	Rock	9%	4%	4%		5%
	Rock/Gravel	4%				1%

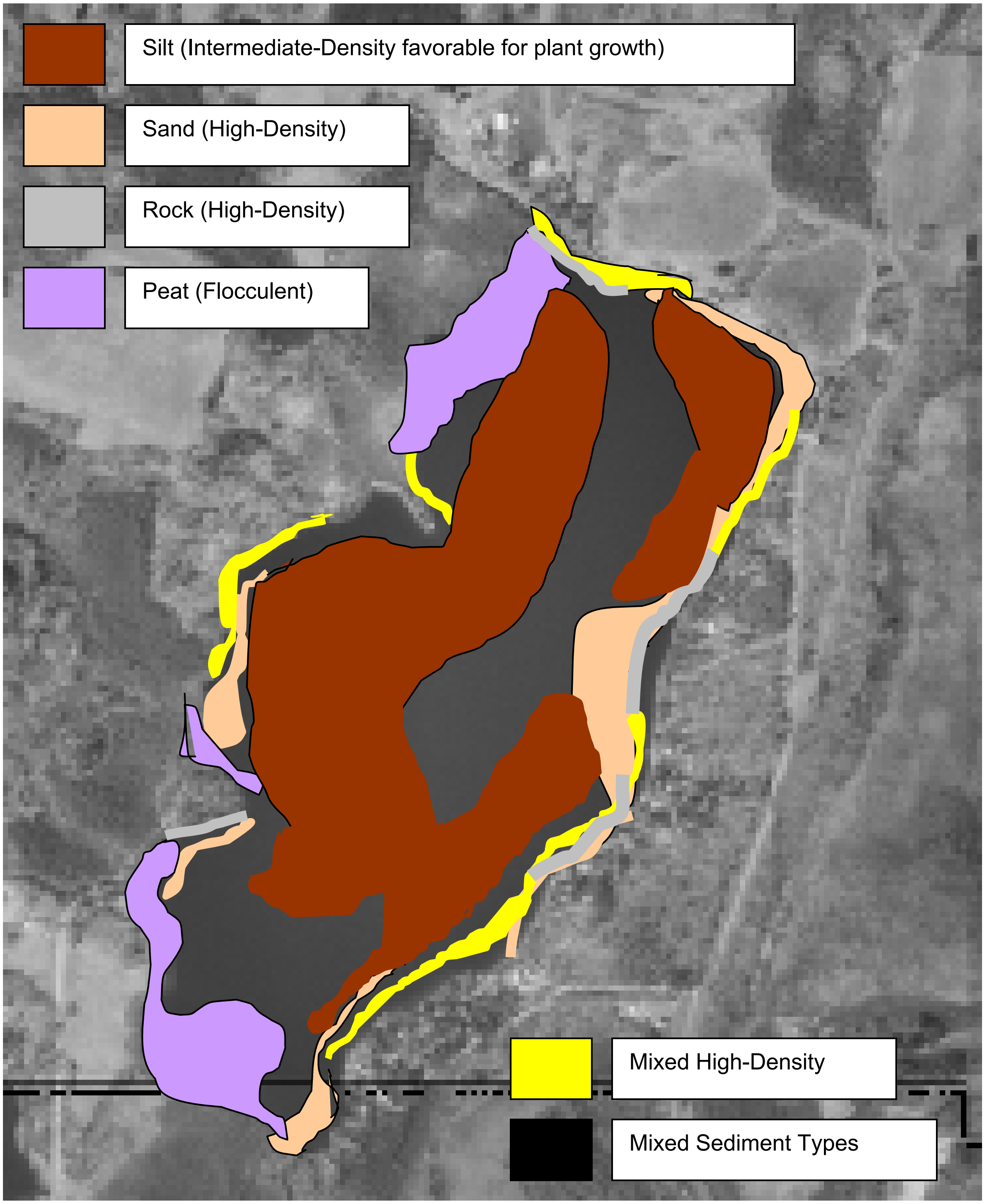

Figure 4. Sediment distribution in Round Lake, 2004.

SEDIMENT INFLUENCE

Some aquatic plants depend on the sediments in which they are rooted for required nutrients. The richness or sterility of the sediments will determine the type and abundance of species that can survive in a location.

Silt was the dominant sediment in Round Lake, especially in the deeper depth zones (Table 4). The availability of the mineral nutrients essential for plant growth is highest in sediments of intermediate density, such as silt (Barko and Smart 1986). Silt, however, supported vegetation at only 35% of the sites at which it occurred (Table 5). This is likely due to the higher occurrence of silt at deeper sites where light could be the limiting factor.

Sand and rock sediments, which are not favorable to plant growth because of the high density and low nutrient availability, were vegetated at 71-100% of the sites. However, they were colonized by species that prefer firm sediments: *Eleocharis acicularis, Eriocaulon aquaticum, Myriophyllum tenellum, Potamogeton gramineus* and *Ranunculus flammula*.

Peat is a loosely consolidated sediment with a low specific gravity and is therefore flocculent and easily resuspended (Garrison 1995). This creates a medium that is too loose for most rooted plants, but peat supported abundant vegetation in Round Lake.

Other sediment types supported adequate vegetation in Round Lake. Sediment does not appear to be a factor in preventing plant growth in Round Lake, but important to determining which species colonize an area. Light availability appears to be more important to limiting aquatic plant growth in Round Lake.

Table 5. Aquatic Plant Occurrence at Sediment Types, 2004.

		2004	
		% Occurrence	**% Vegetated**
Soft Sediments	Silt	20%	**35%**
	Silt/Peat	13%	**82%**
	Peat	17%	**86%**
Mixed Sediments	Sand/Silt or Peat	12%	**80%**
Hard Sediments	Sand	18%	**73%**
	Sand/gravel	8%	**71%**
	Sand/rock	6%	**80%**
	Rock	5%	**75%**
	Rock/Gravel	1%	**100%**

SHORELINE LAND USE

Land use on the shoreline and in the watershed strongly impacts the aquatic plant community. Practices on shore can directly impact the plant community through increased sedimentation from erosion, increased nutrient inputs from fertilizer run-off and soil erosion and increased toxics from farm and urban run-off.

Wooded cover was the most frequently encountered shoreline cover and also had the highest mean coverage. Native herbaceous and shrub growth also had high occurrence at the sample sites and good coverage. However, disturbed shoreline (cultivated lawn, rip-rap/retaining walls and hard structures) were also commonly found at the transects and cultivated lawn had a high mean coverage (Table 6).

Table 6. Round Lake Shoreline Land Use, 2004.

Cover Type		Frequency of Occurrence at Transects	Percent Mean Coverage
		2004	2004
Natural Shoreline	Wooded	82%	30%
	Native Herbaceous	74%	20%
	Shrub	70%	20%
	Rock	17%	1%
Total Natural			70%
Disturbed Shoreline	Cultivated Lawn	35%	20%
	Hard Structures	48%	7%
	Rip-rap/Retaining Wall	26%	2%
	Bare/Eroded Soil	4%	1%
Total Disturbed			30%

Based on coverage at the transect sites, natural shorelines occur at 87% of the sites and protect 71% of the shoreline. Man-made disturbances occur at 52% of the sample sites and impact 30% of the shoreline (Table 6).

MACROPHYTE DATA

SPECIES PRESENT

Forty-eight (48) species of aquatic plants have been found during the 1988-2004 studies: 15 emergents species, 5 floating leaf species, and 28 submergent species (Table 7).

No endangered of threatened species were found in Round Lake, but 10 species were recorded that are listed as Rare, Special Concern species by the Wisconsin Bureau of Endangered Resources:

Ceratophyllum echinatum
Eleocharis robbinsi
Myriophyllum farwelli
Potamogeton capillaceus
Potamogeton diversifolius
Potamogeton vaseyii
Scirpus torreyi
Utricularia geminiscapa
Utricularia purpurea
Utricularia resupinata

Special Concern Species are species with which there is concern about their lack of abundance or distribution. The main purpose of this designation is to focus attention on these species before they become threatened or endangered.

Table 7. Round Lake Aquatic Plant Species, 1988-2004

Scientific Name	Common Name	I. D. Code
Emergent Species		
1) *Carex rostrata* Stokes	sedge	carro
2) *Chamaedaphne calyculata* (L.) Moench.	leatherleaf	chaca
3) *Dulichium arundinacea* (L.) Britton	three-way sedge	dular
4) *Eleocharis robbinsii* Oakes	triangle spikerush	elero
5) *Eleocharis smallii* Britt.	creeping spikerush	elesm
6) *Eriocaulon aquaticum* (Hill) Duce	pipewort	eriaq
7) *Iris versicolor* L.	northern blue flag	irive
8) *Juncus effusus* L.	soft rush	junef
9) *Pontederia cordata* L.	pickerelweed	ponco
10) *Sagittaria graminea* Michx.	grass-leaf arrowhead	saggr
11) *Sagittaria* sp.	arrowhead	sagsp
12) *Scirpus cyperinus* (L.) Kunth.	wool-grass	scicy
13) *Scirpus torreyi* Olney	Torrey's three-square	scito
14) *Scirpus validus* Vahl.	softstem bulrush	sciva
15) *Typha latifolia* L.	broad-leaf cattail	typla
Floating leaf Species		
16) *Brasenia schreberi* J. F. Gmelin	watershield	brasc
17) *Lemna minor* L.	small duckweed	lemmi
18) *Nuphar variegata* Durand.	bull-head pond lily	nupva
19) *Nymphaea odorata* Aiton.	white water lily	nymod
20) *Sparganium fluctuans* (Morong) Robinson	floating-leaf burreed	spafl
Submergent Species		
21) *Ceratophyllum echinatum* A. Gray	spiny hornwort	cerec
22) *Elatine minima* (Nutt.) Fischer & Meyer	waterwort	elami
23) *Eleocharis acicularis* (L.) Roemer & Schultes.	needle spikerush	eleac
24) *Isoetes echinospora* Durieu	quillwort	isoec
25) *Juncus pelocarpus* E. Meyer	brown-fruited rush	junpe
26) *Myriophyllum farwellii* Morong.	Farwell's watermilfoil	myrfa
27) *Myriophyllum heterophyllum* Michx.	various-leaf milfoil	myrhe
28) *Myriophyllum sibiricum* Komarov.	common water milfoil	myrsi
29) *Myriophyllum tenellum* Bigelow	dwarf watermilfoil	myrte
30) *Najas gracillima* (A. Braun) Magnus	northern naiad	najgr
31) *Nitella* sp.	nitella	nitsp
32) *Potamogeton bicupulatus* Fern.	waterthread pondweed	potbi
33) *Potamogeton capillaceus* Poir.	waterthread pondweed	potca
34) *Potamogeton diversifolius* Raf.	snail-seed pondweed	potdi
35) *Potamogeton epihydrus* Raf.	ribbon-leaf pondweed	potep
36) *Potamogeton gramineus* L.	variable-leaf pondweed	potgr
37) *Potamogeton natans* L.	floating-leaf pondweed	potna
38) *Potamogeton oakesianus* Robbins	Oake's pondweed	potoa
39) *Potamogeton pusillus* L.	small pondweed	potpu
40) *Potamogeton robbinsii* Oakes.	fern-leaf pondweed	potro
41) *Potamogeton vaseyi* Robbins.	Vasey's pondweed	potva
42) *Ranunculus flammula* L.	creeping spearwort	ranfl
43) *Utricularia geminiscapa* Benj.	twin-stemmed bladderwort	utrge
44) *Utricularia gibba* L.	creeping bladderwort	utrgi
45) *Utricularia purpurea* Walter	purple bladderwort	utrpu
46) *Utricularia resupinata* B. D. Greene	small purple bladderwort	utrre
47) *Utricularia vulgaris* L.	common bladderwort	utrvu
48) *Vallisneria americana* L.	water celery	valam

FREQUENCY OF OCCURRENCE

Utricularia purpurea was the most frequently occurring species during 1988-2000. The frequency of *U. purpurea* decreased in 2004 and the frequency of *Nymphaea odorata* increased and *N. odorata* become the most frequently occurring species in 2004. Several other species were common (occurring at frequencies > 20%) and have varied in their frequencies (Table 8). The most dramatic change between sample years was the occurrence and sudden abundance of *Myriophyllum heterophyllum* in 1991.

Table 8. Frequencies of Prevalent Aquatic Plants in Round Lake, 1998-2004.

Species	1988	1991	1994	1997	2000	2004
Nymphaea odorata	16%	22%	16%	20%	23%	**27%**
Utricularia purpurea	**41%**	**66%**	**34%**	**38%**	**48%**	18%
Utricularia vulgaris	6%	11%	23%	8%	7%	15%
Pontederia cordata	10%	28%	26%	12%	8%	14%
Myriophyllum heterophyllum	0%	49%	19%	28%	32%	12%
Utricularia gibba	1%	30%	28%	23%	11%	11%
Nitella sp.	31%	40%	22%	38%	19%	5%

DENSITY

In addition to the highest frequency in 1998-2000, *Utricularia purpurea* had the highest mean density (Table 9). The density of *U. purpurea* also decreased in 2004 and the density of *Nymphaea odorata* also increased to become the species with the highest mean density.

Table 9. Densities of Prevalent Aquatic Plants in Round Lake, 1998-2004.

Species	1988	1991	1994	1997	2000	2004
Nymphaea odorata	0.42	0.70	0.50	0.47	0.67	**0.86**
Utricularia purpurea	**1.33**	**2.05**	**0.89**	**0.91**	**1.41**	0.37
Utricularia vulgaris	0.23	0.32	0.47	0.11	0.10	0.32
Pontederia cordata	0.34	0.53	0.47	0.29	0.22	0.23
Myriophyllum heterophyllum		1.31	0.33	0.55	0.67	0.18
Utricularia gibba	0.01	0.63	0.45	0.34	0.14	0.15
Nitella sp.	1.07	1.20	0.78	0.91	0.55	0.10

DOMINANCE

Combining the relative frequency and relative density of a species into a dominance value indicates how dominant a species is within its community. *Utricularia purpurea* had been the dominant species during 1988-2000 (Figure 5). In 2004, *Nymphaea odorata* became the dominant species. Either *Nitella* spp. or *Myriophhyllum heterophyllum* were sub-dominant during 1988-2000. In 2004, *Brasenia schreberi* was the sub-dominant species.

The dominance of *Eriocaulon aquaticum* has steadily declined (Figure 5).

Myriophyllum heterophyllum was not present in the survey in 1988, but suddenly appeared in 1991 as sub-dominant. Its dominance decreased slightly in 1994 and 1997, but again increased in 2000 and declined in 2004 (Figure 5).

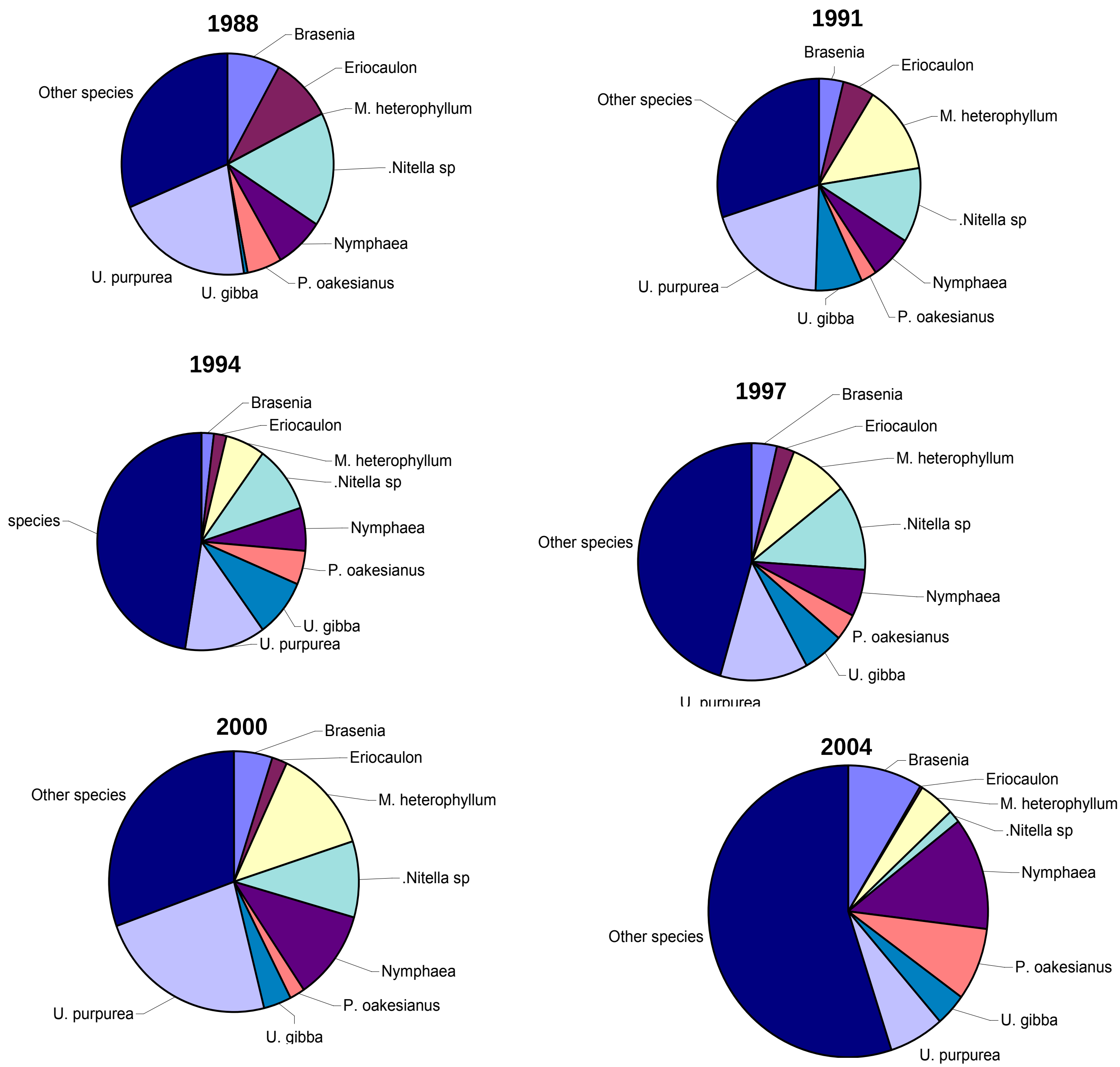

Figure 5. Dominance within the plant community of the prevalent species in Round Lake, based on Dominance Values, 1988-2004.

The dominance of individual species varied among depth zones and year.

In the shallowest depth zone (0-1.5ft), a different emergent or floating-leaf species had the highest dominance each year (Appendices I-XII). In the 0-1.5ft depth zone, *Eriocaulon aquaticum* was the dominant species in 1988, but has steadily declined since then. In 1991, *E. aquaticum* shared dominance in this depth zone with *Pontederia cordata*, and then *P. cordata* was dominant in this shallowest depth zone in 1994. Since 1994, *P. cordata* has declined slightly and shifted its greatest colonization into the 1.5-5ft depth zone. *Nymphaea odorata* and *Sagittaria* spp. have been dominant in the 0-1.5ft depth zone during 1997-2004.

Utricularia purpurea was the dominant species in the 1.5-5ft depth zone in 1988 and 1991. Its dominance in the 5-10ft depth zone increased and it became dominant in the 5-10ft depth zone also in 1991 (Figure 6, 7). *U. purpurea* decreased since 1991, but remained dominant in the 5-10ft depth zone in 2000-2004. In 2000, it was also dominant in the 10-20ft depth zone. *U. purpurea* has occurred at its highest frequency and density in the 5-10 ft. depth zone in all years (Figure 6, 7).

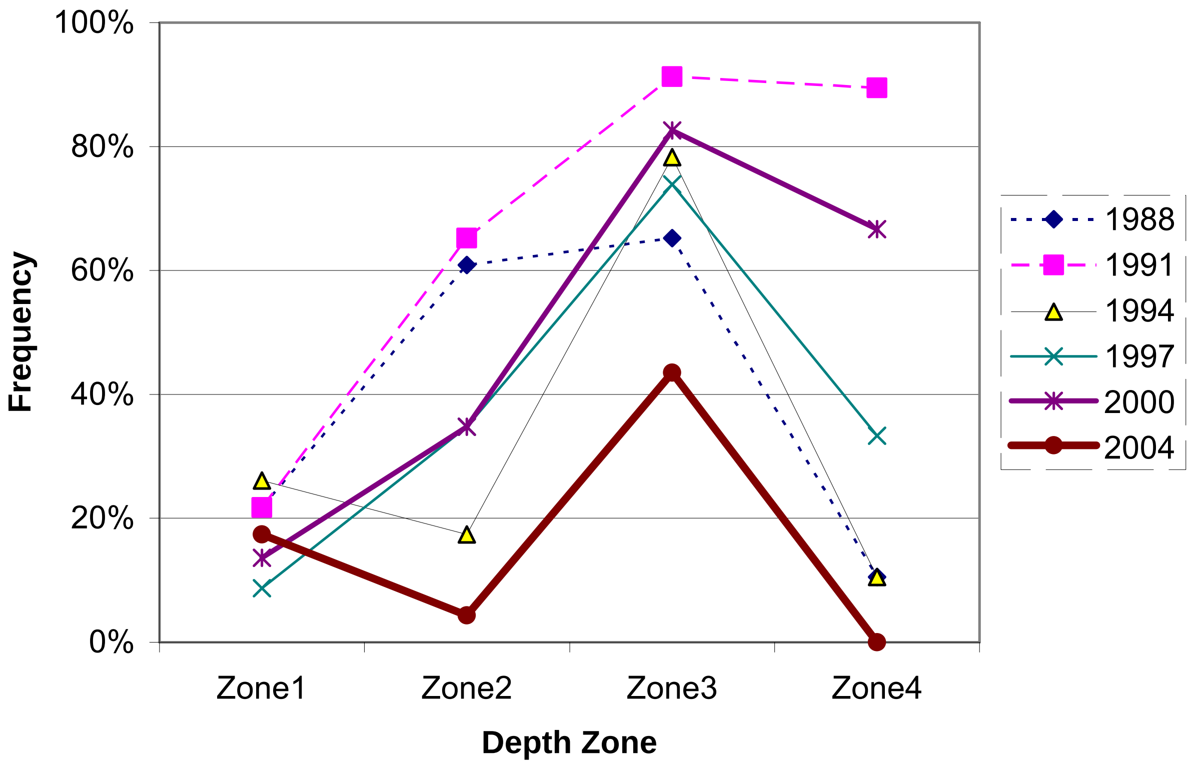

Figure 6. Frequency of *Utricularia purpurea* by depth zone, 1988-2004.

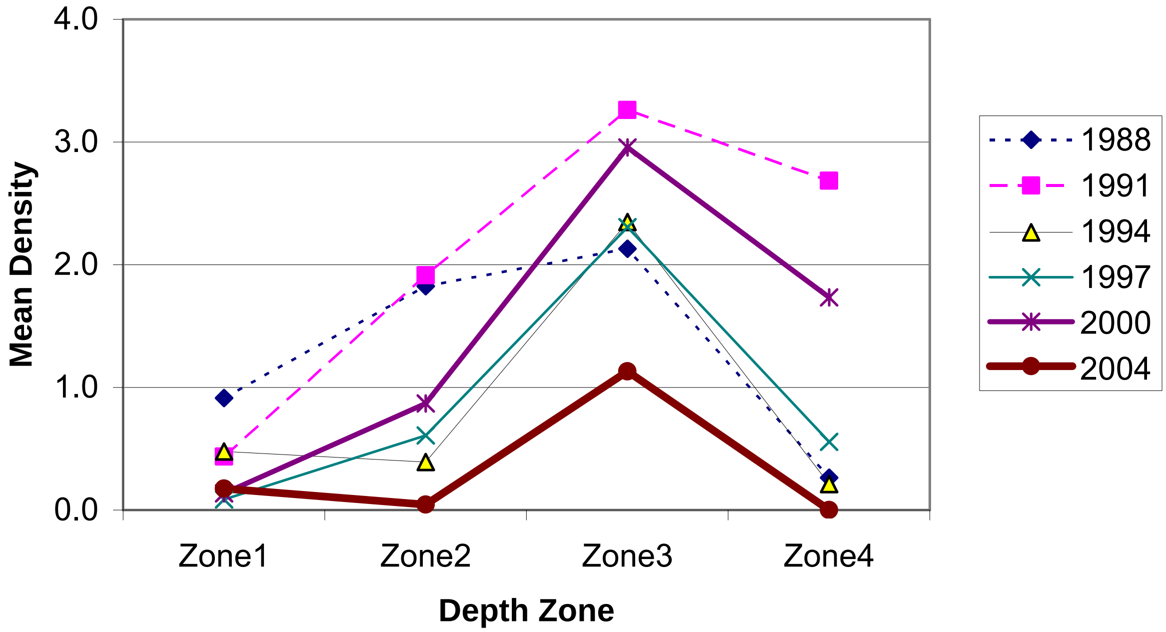

Figure 7. Density of *Utricularia purpurea* by depth zone, 1988-2004.

When *Utricularia purpurea* declined in the 1.5-5ft depth zone after 1991, *Nymphaea odorata* became the dominant species in this zone 1994-2004. *Nymphaea odorata* became more dominant during the last surveys even though its frequency and density of occurrence has remained stable after a slight increase since 1988 (Figure 8, 9). *N. odorata* has occurred at its highest frequency and density in the 1.5-5ft depth zone (Figure 8, 9).

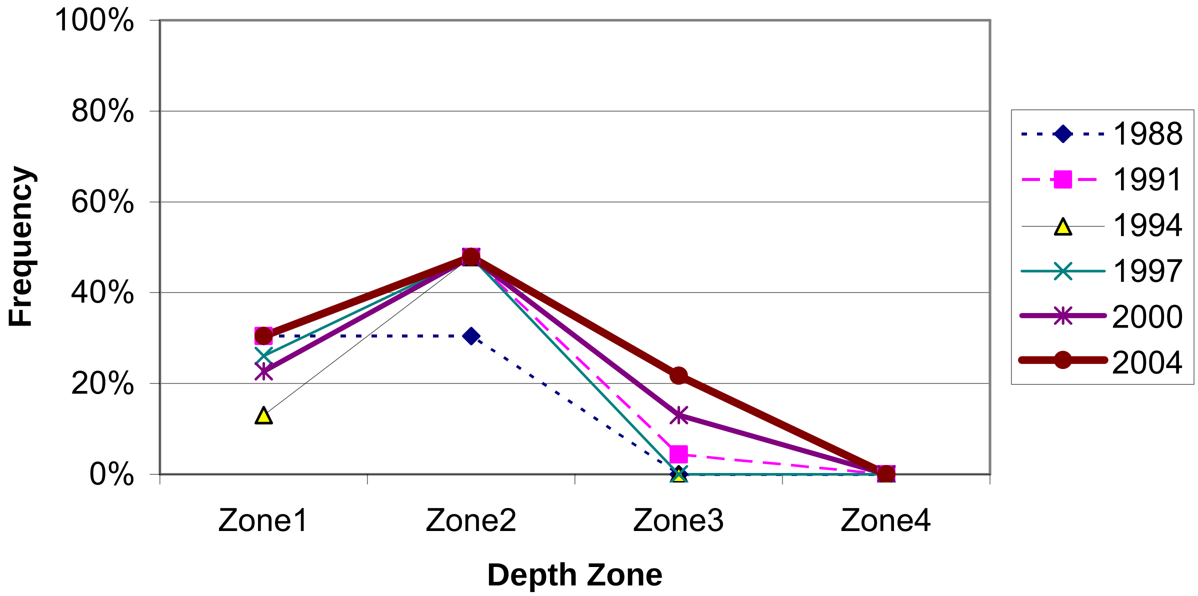

Figure 8. Frequency of *Nymphaea odorata* by depth zone, 1988-2004.

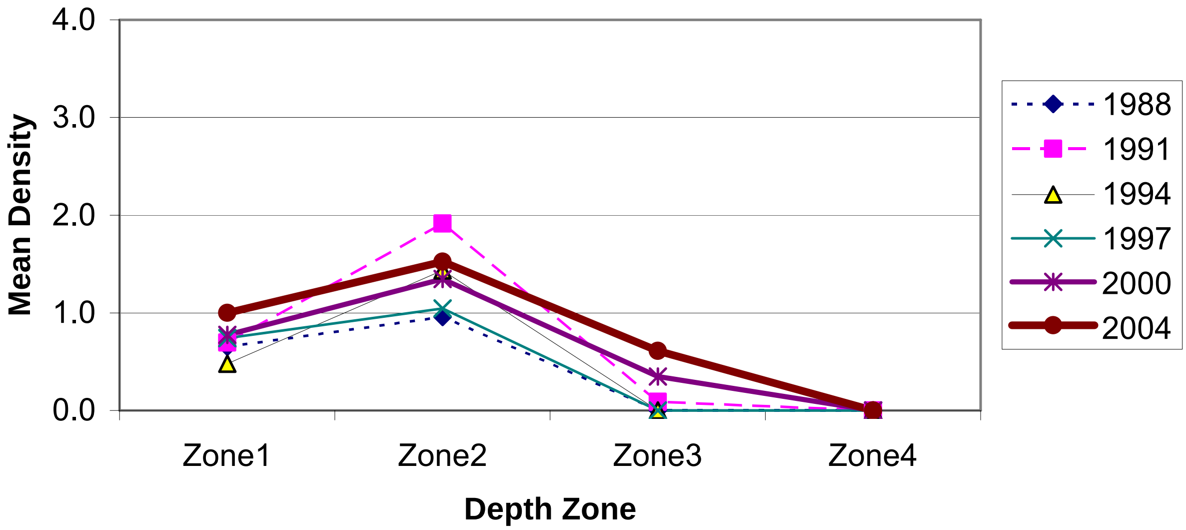

Figure 9. Density of *Nymphaea odorata* by depth zone, 1988-2004.

Nitella spp., a macrophytic algae, was dominant in the 5-10ft depth zone before *Utricularia purpurea* increased and became dominant in later studies (Figure 10, 11).

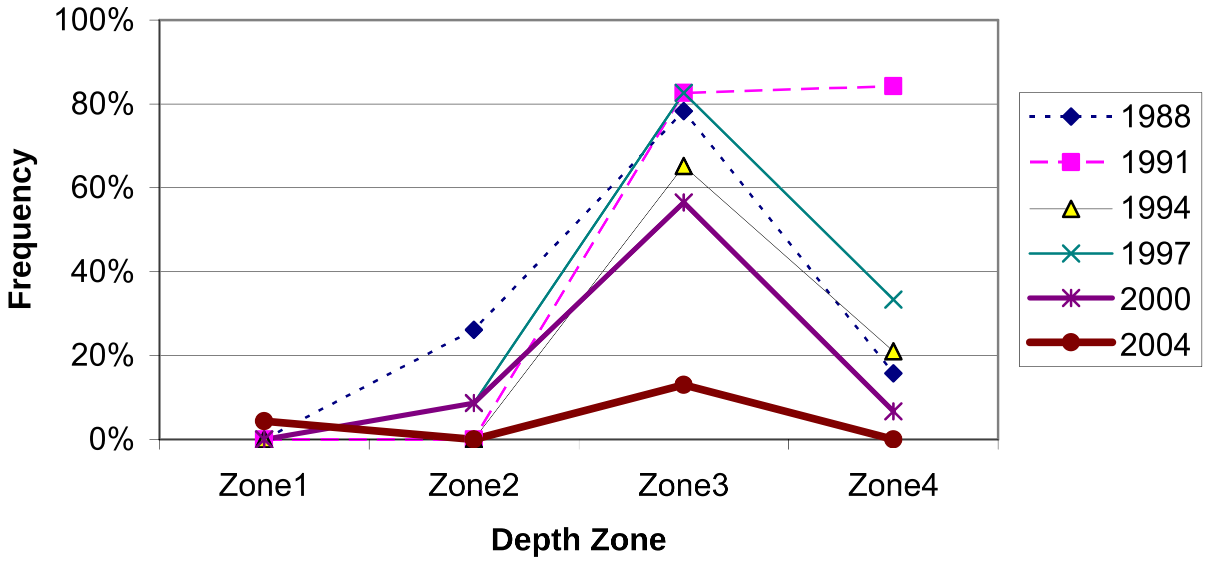

Figure 10. Frequency of *Nitella* sp. by depth zone, 1988-2004.

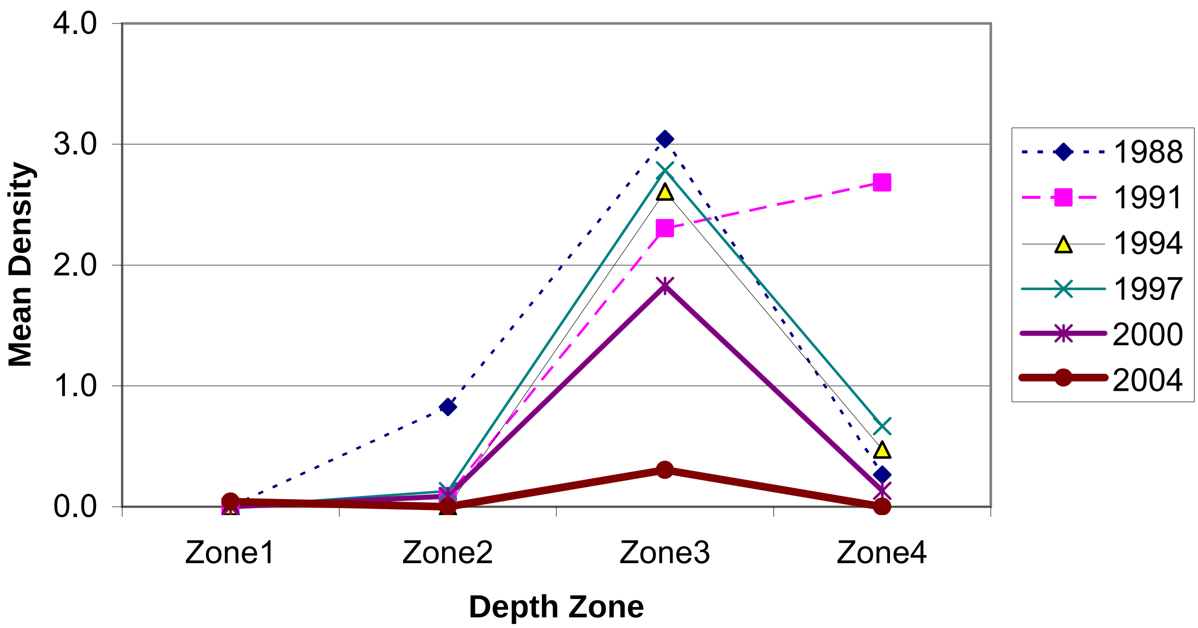

Figure 11. Density of *Nitella* sp. by depth zone, 1988-2004.

DISTRIBUTION

In all study years, aquatic plants occurred throughout the littoral zone, with rooted vegetation found at all vegetated sampling sites. Within in the littoral zone, aquatic plants occurred at 66% to 89% of all sampling sites during 1988 - 2004. Some type of aquatic vegetation occurred in approximately 110 acres of the lake in 2004, however the majority of the vegetation along the east and north shores was composed of low growing rosette, turf-forming species. This is approximately 50% of the entire lake surface (Figure 12).

The dominant and common species were found only in the littoral zones on the south and west sides of the lake. *Utricularia purpurea* and *Sagittaria* rosettes were the most widely distributed species. *U. purpurea* was recorded along the north, west and south shores; *Sagittaria* spp. was recorded along the west shore, south shore and south half of the east shore.

Nitella spp., aquatic moss and *Utricularia purpurea* have occurred at the greatest depth. However, these species are not truly rooted. *Nitella* is an algae with rhizoids, not true roots and *U. purpurea* is a free-floating species with minimal anchoring structures. The deepest rooted plant growth was *Potamogeton diversifolius* at 6' in 1988 and *Myriophyllum heterophyllum* at 10.5 - 12ft in 1991 - 2000. *Isoetes echinospora* was recorded at the maximum rooting depth in 2004 (12ft).

The predicted maximum rooting depth can be calculated from Secchi Disc water clarity data (Dunst 1982) (Figure 13).

Predicted Rooting Depth (ft.) = (Secchi Disc (ft.) * 1.22) + 2.73

The actual maximum rooting depth has been slightly deeper than the predicted maximum rooting depths, based on water clarity since 1991. This may be due to better clarity in the spring when plants are beginning their growth.

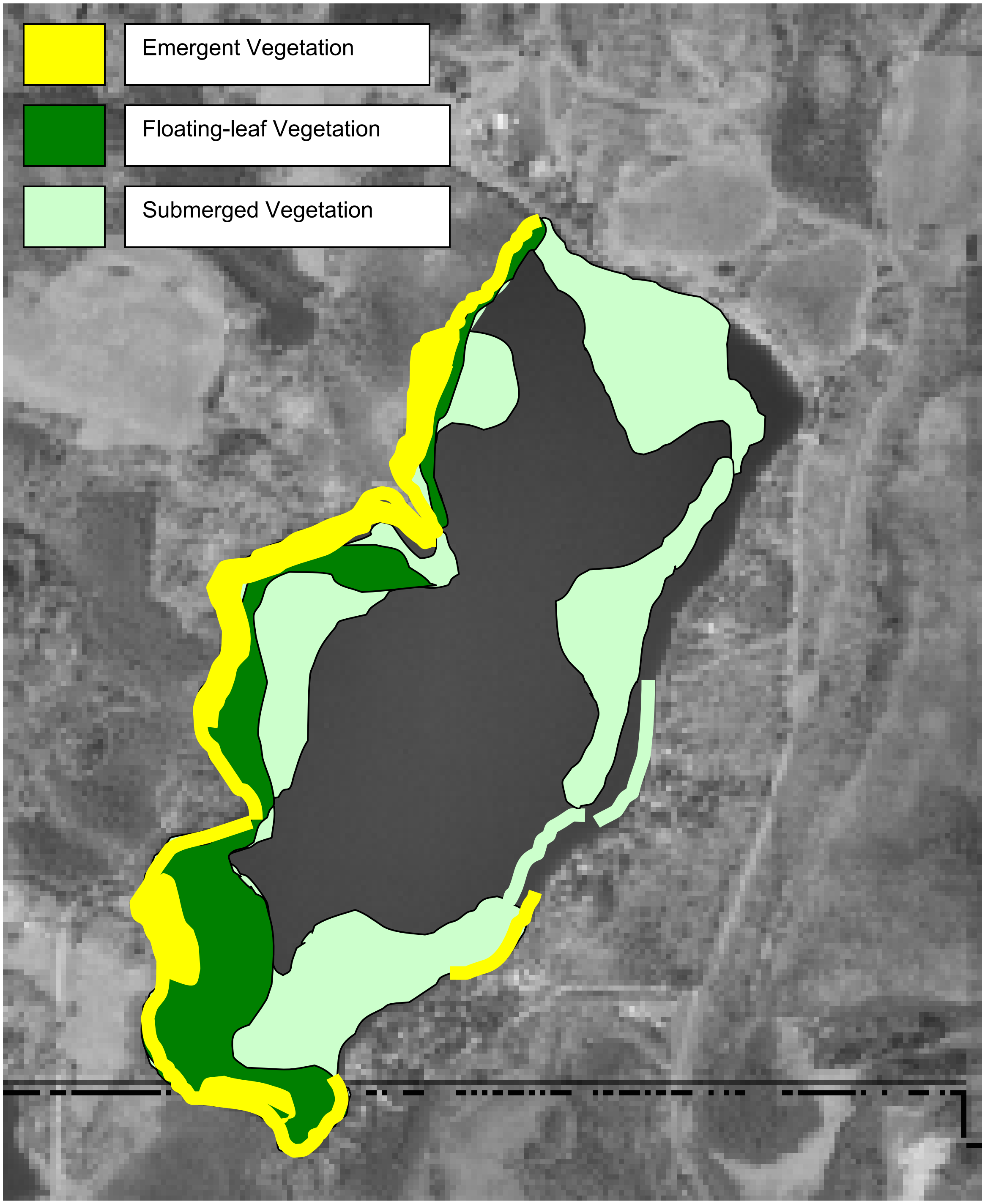

Figure 12. Distribution of aquatic vegetation in Round Lake, 2004.

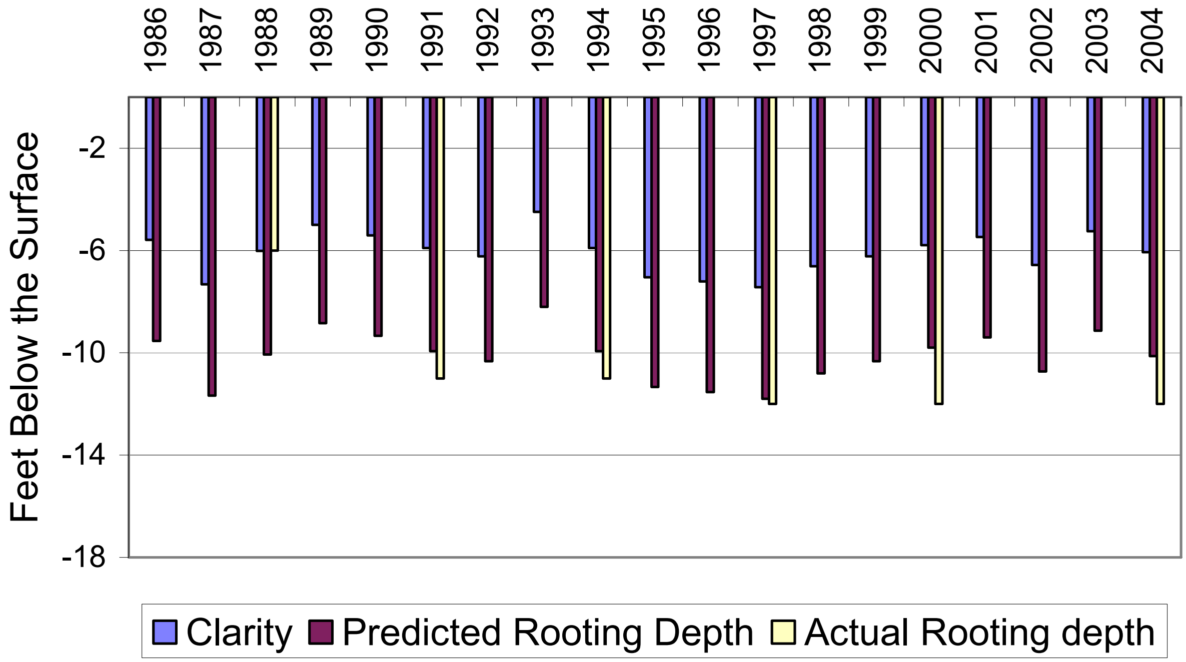

Figure 13. Comparison of predicted and actual maximum rooting depth in Round Lake, 1988-2004.

The percentage of vegetated sites varies with depth zone (Figure 14). The depth zone with the greatest percent of vegetated sites has been the 5-10ft-depth zone. The lowest percent of vegetated sites was in 1994 and the highest percent of vegetated sites was in 1997.

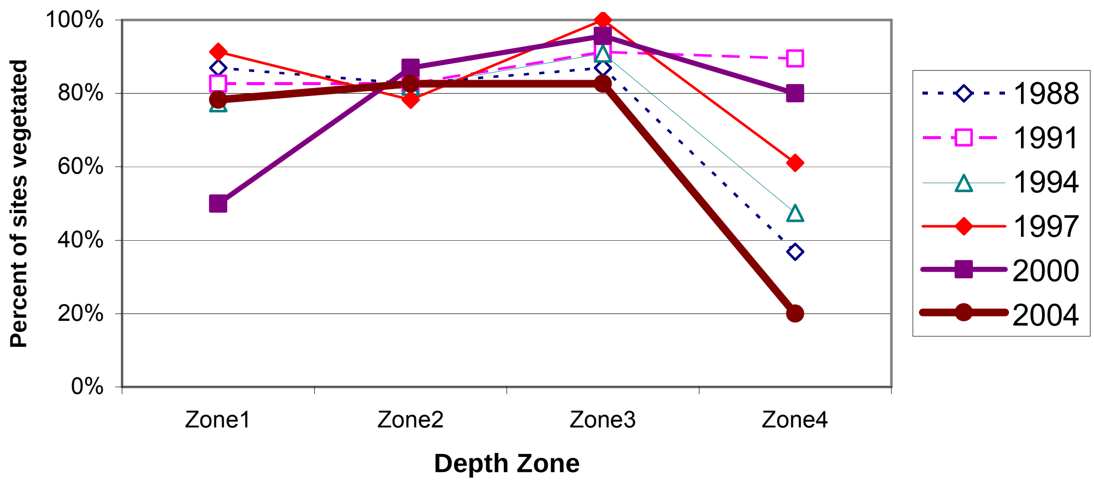

Figure 14. Percent of sample sites vegetated, by depth zone, 1988-2004.

The depth zone with the highest total occurrence of vegetation was the 0-1.5ft zone in 1988, shifting to the 1.5-5ft zone in subsequent years, until 2004, when the highest total occurrence of plants shifted back to the 0-1.5ft depth zone (Figure 15). There has been a sharp decline in the occurrence of aquatic plant growth in the 10-20' depth zone.

The lowest occurrence of plants was recorded in 1988; the highest occurrence was in 1991. Occurrence of plant growth declined slightly in 1994 and 1997 and declined more dramatically in the 0-1.5ft-depth zone in 2000 (Figure 15). Total occurrence of plants increased slightly in 2004.

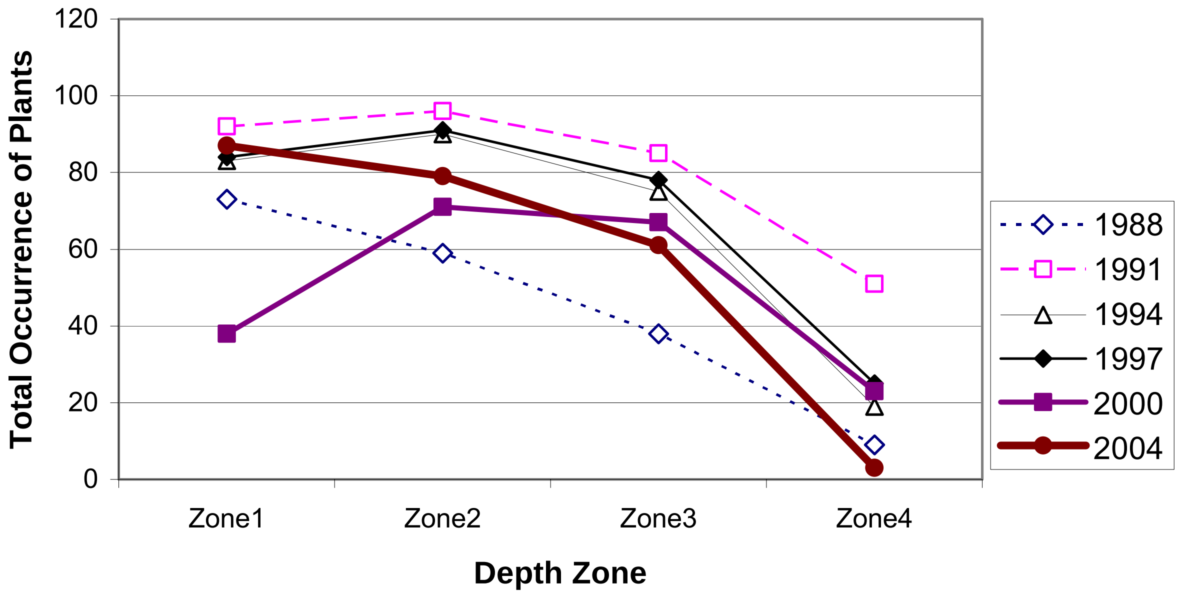

Figure 15. Total occurrence of aquatic plants by depth zone, 1988-2004.

The depth zone with the highest total density of vegetation was been shifting into the deeper depth zones, from the 0-1.5ft depth zone in 1988, to the 5-10ft depth zone in 2000 (Figure 16). In 2004, the depth zone with the highest total density of plant growth started shifting back into shallower zones, into the 1.5-5ft depth zone again.

The plant community was at its highest density in 1991 and lowest density in 2000 and 2004 (Figure 16).

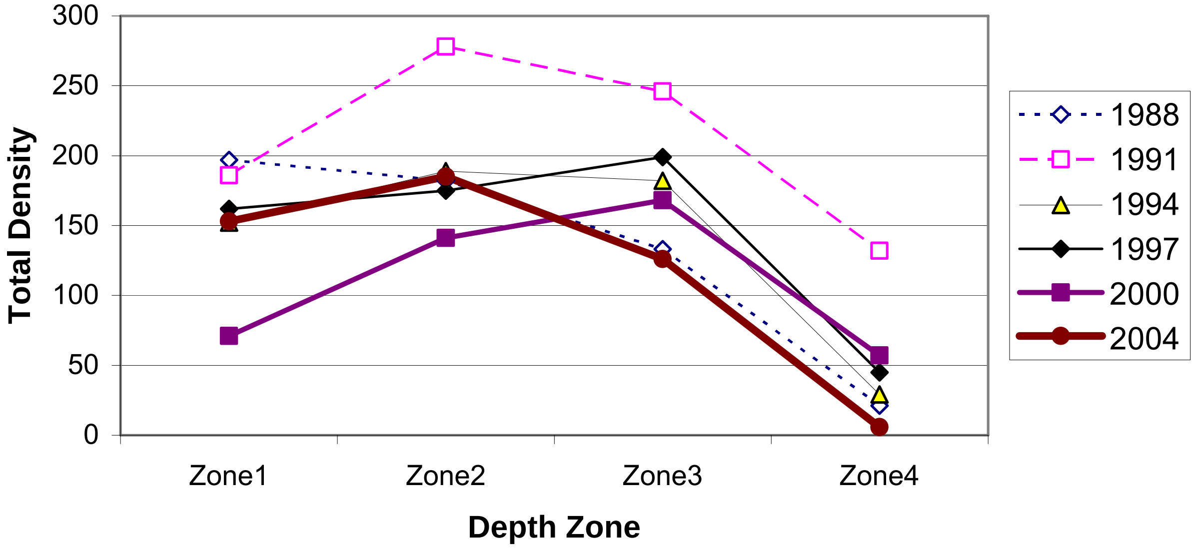

Figure 16. Total density of aquatic plants by depth zone, 1988-2004.

The highest Species Richness (mean number of species per sample site) was in the 0-1.5ft depth zone in 1988 (Figure 17). During 1991-2000, the greatest species richness increased and shifted into the 1.5-5ft depth zone, except for a overall decrease in species richness in 2000. In 2004, overall species richness increased slightly and the greatest richness shifted back to the 0-1.5ft depth zone. The overall Species Richness ranged between a low of 1.98 (1988) to a high of 3.51 (1994) during the trend study. In 2004, overall species richness in Round Lake was 2.74.

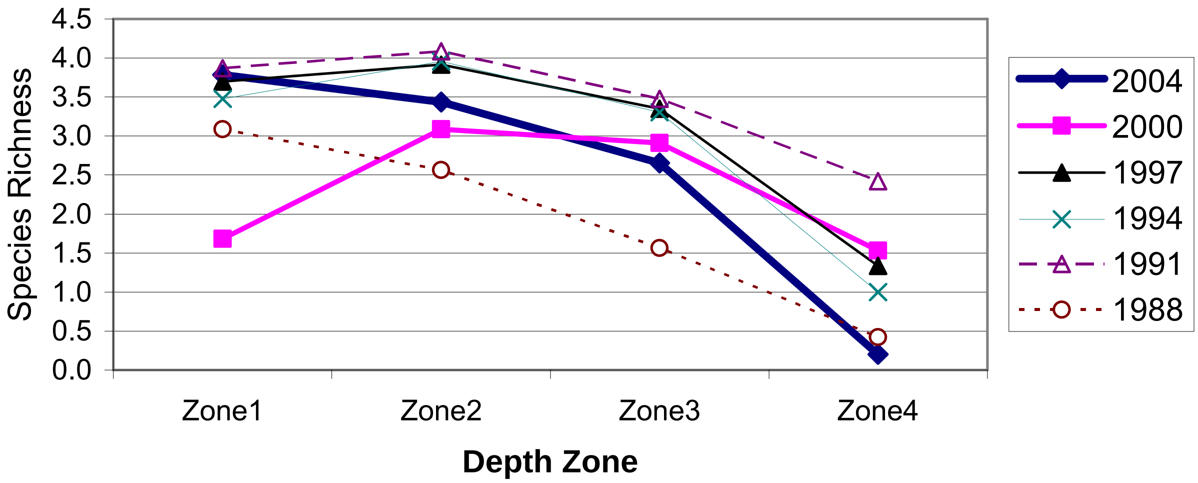

Figure 17. Species Richness, by depth zone, 1988-2004.

MACROPHYTE COMMUNITY

The Coefficient of Community Similarity is a measure of the percent similarity between two communities. Coefficients less than 75% indicate that the two communities are less than 75% similar and are considered significantly different.

The coefficients for Round Lake indicate that the aquatic plant community in Round Lake has changed (Table 10). The plant community changed significantly between 1988 and 1991 when *Myriophyllum heterophyllum* first appeared: only 66% similar.

The 1991 to 2004 plant communities were not significantly different, being 73-78% similar (Table 10).

However, the community changed significantly again between 2000 and 2004: only 61% similar.

The additive changes in the plant community over the 17 years of aquatic plant studies has resulted in the 2004 plant community being only 58% similar to the aquatic plant community of 1988 (Table 10), a significant change. This means that only 58% of the 1988 community has been retained in the 2004.

Table 10. Coefficients of Community Similarity.

Coefficients of Community Similarity		% Similar
1988-1991	0.6555	66%
1991-1994	0.7257	73%
1994-1997	0.7751	78%
1997-2000	0.7390	74%
2000-2004	0.6110	61%
1988-2004	0.5858	58%

Several indices can be used to assess the details of changes within the aquatic plant community.

The total number of species recorded at the sample sites, the Simpson's Diversity index and the species richness (mean number of species at each sample site) have all increased (Table 11). Simpson’s Diversity Index measures the diversity of plant species in the plant community. A Simpson's Diversity index of 1.0 would mean that each individual in a community was a different species, the most diversity that could be found. The diversity index for Round Lake has varied between very good diversity in 1988 (0.90) to excellent diversity in 2004 (0.95) (Table 11). Plant communities with higher diversities are valuable, because high diversity in the plant community supports a more diverse assemblage of invertebrates, fish and wildlife.

Other parameters that have increased since 1988 are the maximum rooting depth of plant growth, the percent colonization of emergent species and floating-leaf species (lily pad types), the plant community's sensitivity to disturbance (Average Coefficient of Conservatism, discussed later), the plant community's closeness to an undisturbed condition (Floristic Quality Index, discussed later) and the quality of the aquatic plant community (AMCI, discussed later). The greatest percentage of increase has been in the maximum rooting depth, which has doubled since 1988 (Table 11).

The only decrease has been a 25% decrease in the area colonized by submergent vegetation (Table 11).

Table 11. Changes in the Aquatic Plant Community, Round Lake, 1988-2004.

	1988	1991	1994	1997	2000	2004	%Change
Number of Species	21	28	33	32	27	37	76.2%
Maximum Rooting Depth	6	11	11	12	12	12	100.0%
% of Littoral Zone Vegetated	70	86	66	83	78	70	0.0%
%Sites/Emergents	13.6	20.5	27.3	25.3	14.5	23.8	75.0%
%Sites/Free-floating		1.1			4.8	0.0	
%Sites/Submergents	73.9	63.6	71.6	75.9	74.7	54.8	-25.8%
%Sites/Floating-leaf	20.5	21.6	17.0	19.5	22.9	28.6	39.5%
Simpson's Diversity Index	0.90	0.91	0.94	0.94	0.91	0.95	5.6%
Average Coefficient of Conservatism	7.58	7.46	7.52	7.73	8.00	7.94	4.7%
Floristic Quality	33.04	38.05	41.85	42.36	40.00	46.30	40.1%
AMCI	57	65	63	66	65	58	1.8%
Species Richness	1.98	3.51	3.02	3.17	2.38	2.74	38.4%

The Aquatic Macrophyte Community Index (AMCI), developed for Wisconsin lakes (Nichols 2000), was applied to Round Lake. According to the AMCI value, the aquatic plant community in Round Lake is well above average. The value increased between 1988 and 1991 due to the increase in maximum rooting depth and an increase in the number of species. The quality declined in 2004 due to declines in sensitive species and the cover of submergent species.

Table 12. Aquatic Macrophyte Community Index (AMCI), Round Lake, 1988-2004.

	1988	1991	1994	1997	2000	2004
Maximum Rooting Depth	2	6	6	6	6	6
% Littoral Zone Vegetated	10	10	10	10	10	10
Simpson's Diversity Index	9	9	10	10	9	10
Relative Frequency of Submersed Species	7	10	7	10	10	5
Relative Frequency of Sensitive Species	10	10	10	10	10	7
# of Taxa	9	10	10	10	10	10
Relative % of Exotic Species	10	10	10	10	10	10
Total	57	65	63	66	65	58

The maximum AMCI value is 70.

Nichols (1998) method for evaluating the closeness of an aquatic plant community to an undisturbed condition using Coefficients of Conservatism was applied to Round Lake.

The 1988 – 2004 the Average Coefficients of Conservatism for Round Lake were within the upper quartile for all Wisconsin lakes. During 1988-1994, Round Lake was above the mean for lakes in the Northern Forest and Lakes Region; in 1997-2004, Round Lake was in the upper quartile of lakes in the region also (Table 13). This suggests that Round Lake is among the group of lakes in the state and region most sensitive to disturbance.

Table 13. Mean Coefficient of Conservatism and Floristic Quality of Round Lake, Compared to Wisconsin Lakes and Region Lakes.

	Average Coefficient of Conservatism †	Floristic Quality ‡
Wisconsin Lakes	5.5, 6.0, 6.9*	16.9, 22.2, 27.5*
NLFR Lakes	6.1, 6.7, 7.7*	21.9, 28.3, 36.6*
Round Lake, 1988-2004		
1988	7.58	33.04
1991	7.46	38.05
1994	7.52	41.85
1997	7.73	42.36
2000	8.00	40.00
2004	7.94	46.30

Based on Nichols study of 554 lakes throughout Wisconsin:

* Values indicate the upper limit of lower quartile, mean, lower limit of upper quartile

† Average Coefficient of Conservatism for all Wisconsin lakes ranged from a low of 2.0 (the most disturbance tolerant), to a high of 9.5 (least disturbance tolerant)

‡ Floristic Quality ranged from a low of 3.0 (farthest from an undisturbed condition) to a high of 44.6 (closest to an undisturbed condition).

NLFR (Northern Lakes and Forest Region) the region in which Round Lake is located.

The Floristic Quality Index (FQI) for Round Lake was in the upper quartile for Wisconsin Lakes for all years. The FQI was above the mean for lakes in the North Lakes and Forest Region in 1988 and in 1991-2004; the Floristic Quality had increased and was in the upper quartile of lakes in the North Lakes and Forest Region (Table 13). In 2004, the Floristic Quality was higher than any encountered during the study by Nichols (1998).

This suggests that the plant community in Round Lake is within the group of lakes in the state and region closest to an undisturbed condition and may be one of the few lakes closest to an undisturbed condition.

Disturbances can be of many types:

1) Direct disturbances to the plant beds result from boat traffic, plant harvesting, chemical treatments, the placement of docks and other structures, etc.
2) Indirect disturbances can be the result of factors that impact water clarity and thus stress species that are more sensitive: resuspension of sediments, sedimentation from erosion, increased algae growth due to nutrient inputs.
3) Biological disturbances include the introduction of a non-native or invasive plant species that may crowd out the more sensitive species, grazing from an increased population of aquatic herbivores, destruction of plant beds by the

fish population, etc.

Aquatic plant communities change because individual species within the community have changed in frequency and density over the study years (Appendix XX).

Between 1988 and 2004, fifteen species increased in frequency, density and dominance: *Brasenia schreberi, Chamaedaphne calyculata, Elatine minima, Isoetes echinospora, Myriophyllum farwelli, M. tenellum, Nuphar variegata, Nymphaea odorata, Potamogeton diverisfolius, P. oakesianus, Sagittaria* spp., *Scirpus torreyi, Utricularia geminiscapa, U. gibba* and *U. vulgaris. Utricularia gibba* has increased the most, increasing by a factor of more than 8 in frequency.

Five species have decreased since 1988: *Eleocharis smallii, Eriocaulon aquaticum, Nitella* spp., *Utricularia purpurea* and aquatic moss. *Eriocaulon aquaticum* has undergone the largest decrease, 94% in frequency and 97% in density.

Twenty-two species either 1) have not increased or decreased or 2) occur at very few sites and do not appear in all study years and may be missed by shifting of the transects slightly.

Two species that did not occur in 1988, but found in 1991, have declined steadily since 1991: *Ceratophyllum echinatum* and *Myriophyllum heterophyllum.*

IV. DISCUSSION

Water Quality

Based on water clarity and the concentration of chlorophyll and phosphorus (1988-2004), Round Lake is a mesotrophic lake with fair water quality and clarity. Filamentous algae first appeared during the aquatic plant surveys in 1997.

The input of phosphorus from the watershed is very low, due to two important factors. The first is that the watershed is relatively small size as compared to lake size. The second is that natural vegetated cover protects 92% of the watershed.

The Aquatic Plant Community

Aquatic plant growth in Round Lake is favored by the large percentage of shallow, gradually-sloped littoral zone, the dominance of silt sediments favorable to plant growth and adequate nutrients (mesotrophic status). The soft water and high percentage of either sand or loosely consolidated peat sediments in the 0-5 ft depth zone could limit plant growth.

From 1988 to 2004, 48 species have been found during the plant surveys, including ten species listed as Rare, Special Concern species by the Bureau of Endangered Resources. Many species in Round Lake are typical of soft water, bog lakes. Of the species that have a preference for substrate, 71% prefer soft substrates. *Nymphaea odorata* was the dominant species in 2004, especially in the 1.5-5ft depth zone, exhibiting a dense growth form in Round Lake. *Brasenia schreberi* was sub-dominant, exhibiting a growth form of above average density.

Aquatic plants occurred throughout the littoral zone at 70% of the sites, 50% of the entire lake. The most prevalent species are distributed throughout the lake. Three prevalent species were found only in the littoral zones along the west and south bog shores. The maximum rooting depth is 12 feet, slightly deeper than the predicted maximum rooting depth, based on water clarity. This is likely due to better water clarity early in the season when plants are first starting their growth. *Isoetes echinospora* occurred at the maximum rooting depth in 2004.

Round Lake has an excellent diversity of aquatic plant species; Species Richness is 2.74 species per site. The Aquatic Macrophyte Community Index (AMCI) indicates that the quality of the aquatic plant community is above average. The Average Coefficient of Conservatism suggests that Round Lake is within the 25% of the lakes in Wisconsin and the Northern Lakes and Forest Region that are least tolerant of disturbance. The Floristic Quality Index for Round Lake is one of the highest in the state and region, indicating that it is very close to an undisturbed condition.

Changes in the Aquatic Plant Community, 1988-2004

The Coefficients of Community Similarity indicate that the aquatic plant community in

Round Lake has changed significantly. The coefficient of similarity between the 1988 and 2004 aquatic plant communities was 0.58, suggesting that enough changes have taken place within the aquatic plant community over the seventeen years of studies that only 58% of the original community has been retained in the present community. A significant change occurred between 1988 and 1991 when *Myriophyllum heterophyllum* and *Ceratophyllum echinatum* first appeared and between 2000 and 2004 when there was a change in the dominant and sub-dominant species for the first time.

Utricularia purpurea had been the dominant plant species during 1988-2000, especially in the 5-10ft depth zone. The dominance of *Nymphaea odorata* increased and it became the dominant species in 2004. *Nitella* spp. and *Myriophyllum heterophyllum* were the sub-dominant species in 1988-2000 until *Brasenia schreberi* became sub-dominant in 2004. *Myriophyllum heterophyllum* was first found in 1990 when it was generating a large number of fragments that were washing onto the shore. *M. heterophyllum* can spread readily from plant fragments; therefore, boat traffic can facilitate the rapid spread of this species. In the 1991 survey, *Myriophyllum heterophyllum* appeared at nearly half of the sites (48.9%), as a sub-dominant species with *Nitella* sp. The frequency and density of *M. heterophyllum* has cycled up and down since, but its frequency and density in 2004 was the lowest since it first appeared.

Since 1998, the changes that have been measured in the aquatic plant community:

1) An increase (doubling) of the maximum rooting depth
2) Increases in the number of species recorded at the sites and in species richness
3) An increase in species diversity (from very good to excellent diversity)
4) Increases in the coverage of emergent and floating-leaf vegetation
5) A slight increase in the quality of the aquatic plant community (AMCI Index)
6) Increased closeness to an undisturbed condition and increased sensitivity to disturbance (Floristic Quality Index and Average Coefficient of Conservatism)
7) The depth zone with the greatest plant growth has shifted from the 0-1.5ft depth zone in 1988, to the 1.5-5ft depth zone in 1991, the 1.5-10ft depth zone in 1994-2000 and expanded to the 0-5ft depth zone in 2004.
8) The appearance of filamentous algae at the sample sites in 1997.

The study year in which the aquatic plant growth appeared to be at its peak was 1991. During the study, not only was occurrence and dominance of the dominant species highest, but the total occurrence and density of all plant growth was at its peak.

A number of species in Round Lake are considered sensitive species (Davis and Brinsom 1980, Swink and Wilhelm 1994, Nichols 1998). These species tend to disappear with alterations or increased disturbance in an ecosystem. The sensitive species found in Round Lake include:

<u>Six small rosette species</u>

Elatine minima, Eriocaulon aquaticum, Isoetes echinospora, Juncus pelocarpus, Myriophyllum tenellum, Ranunculus flammula
<u>Two pondweeds</u>
Potamogeton oakesianus, P. vaseyii

<u>Four bladderworts</u>
Utricularia gibba, U. geminiscapa, U. purpurea, U. resupinata

<u>Five other submerged species</u>
Eleocharis robbinsii, Ceratophyllum echinatum, Myriophyllum farwellii, Scirpus subterminalis, Sparganium fluctuans

<u>Five emergent species</u>
Chaemadaphne calyculata, Dulichium arundinaceum, Pontederia cordata, Sagittaria graminea, Scirpus torreyi

These sensitive plants are indicators of good water quality and low disturbance. Of these 22 sensitive species, 2 species have declined during the study years, 6 have increased and most have remained fairly stable in Round Lake. Thirteen of these 22 species (more than half) occur at only a very few sites and disturbance in that area could obliterate them from the lake. One of these sensitive species that now occur at only one site, *Eriocaulon aquaticum,* has declined dramatically since 1988. In 1988, *E. aquaticum* was the dominant species in the 0-1.5 ft. depth zone; in 1991, *E. aquaticum* was the species with the greatest density in the 0-1.5 ft. depth zone. Currently this species occurs at only one site and may be on the verge of extinction in Round Lake.

Shoreline Impacts
Much of the shoreline on Round lake is protected by native plant growth (wooded, shrub and herbaceous). However, cultivated lawn, hard structures and rip/rap/retaining walls were commonly found at the sample sites. Cultivated lawn alone covered nearly one-quarter of the shoreline and all man-made lake shore disturbances impacts nearly 1/3 of the shoreline on Round Lake. Cultivated lawn and hard structures can result in increased run-off to the lake. Cultivated lawn can also contribute to pesticide and nutrient contamination via run-off of lawn chemicals. Rip-rap and retaining walls do not filter run-off to the lake and do not protect the shoreline as well as natural vegetation.

Transects at shoreline with 100% natural cover on Round Lake were separated from transects that had some disturbed cover and analyzed (Appendices XXII-XXIV). Many measures of the aquatic plant community differed between natural shoreline sites and disturbed shoreline sites (Table 14).

At the natural shoreline transects, the plant community had a greater number of species and a higher Species Richness (species per site) (Table 14). These measures of greater diversity in the plant community at natural shorelines indicate that the community will support greater diversity in the fish and wildlife community.

The natural shoreline sites had a greater percentage vegetation cover and a greater percentage cover of all types of vegetative structure: submergent, floating-leaf and emergent vegetation. This means more diversity of structure for the habitat with the emergent and floating-leaf beds being very important components of quality habitat.

The Average Coefficient of Conservatism and Floristic Quality was higher at the natural sites, indicating that the aquatic plant community at the natural sites are more sensitive to disturbance and closer to an undisturbed condition. This corroborates that the disturbance can imp[act the aquatic plant community (Table 14).

The seven Special Concern Species, that have the highest sensitivity to disturbance were missing or occurred at a lower frequency at the disturbed sites (Table 14). Conversely, the two most tolerant species in Round Lake occurred at a higher frequency at the disturbed shorelines (Table 14).

Table 14. Comparison of the Round Lake Aquatic Plant Community at Natural and Disturbed Shorelines, 2004

		Natural	Disturbed
Number of Species		33	28
Species Richness	**Overall**	**3.70**	**1.86**
	0-1.5ft zone	5.27	2.42
	1.5-5ft zone	5.09	1.92
	5-10ft zone	3.09	2.25
% of Littoral Zone Vegetated		75%	66%
%Sites/submergent vegetation		70%	66%
%Sites/Floating-leaf vegetation		45%	14%
%Sites/emergent vegetation		32%	4%
Average Coefficient of Conservatism		8.20	7.85
Floristic Quality		44.91	40.01
Relative Frequency of Most Sensitive Species (Special Concern Species)		**89%**	**27%**
Ceratophyllum echinatum		8%	4%
Eleocharis robbinsii		28%	4%
Myriophyllum farwellii		8%	4%
Potamogeton diversifolius		10%	4%
P. vaseyi		2%	0%
Scirpus torreyi		5%	2%
Utricularia purpurea		28%	9%
Relative Frequency of Most Disturbance Tolerant Species: Most likely occur in disturbed		**0%**	**4%**
Juncus effusus		0%	2%
Typha latifolia		0%	2%

V. CONCLUSIONS

Round Lake is a shallow soft water lake with bog fringe along two shorelines. It is a mesotrophic lake with fair water clarity and quality. Filamentous algae was first recorded in Round Lake in 1997.

The aquatic plant community is composed of many soft water, bog species. Forty-eight species have been recorded in Round Lake, 10 of these species are designated by the Bureau of Endangered Resources as rare species of Special Concern. The plant community colonized 70% of the littoral zone to a maximum depth of 12 feet, most abundant along the west and south bog fringes.

In 2004, *Nymphaea odorata* was the dominant species, especially in the 1.5-5ft depth zone. *Brasenia schreberi* was sub-dominant. Both dominant and sub-dominant species exhibited a growth form of above average density in Round Lake.

The aquatic plant community in Round Lake is characterized by above average quality, excellent species diversity, high sensitivity to disturbance and an extreme closeness to an undisturbed condition. This suggests that Round Lake has been subjected to fewer disturbances, but also means that it could be most damaged by increased disturbance.

There has been significant change in the aquatic plant community in Round Lake during 1988-2004. The 1988 and 2004 communities are only 58% similar (Coefficients of Community Similarity).

1) The most significant change was the appearance and increased dominance of *Myriophyllum heterophyllum* in 1990. This plant species spreads readily from fragments. By 1991, *M. heterophyllum* was sub-dominant species.
2) There has been a change in species dominance from *Utricularia purpurea* to *Nymphaea odorata.*
3) The depth zone with the greatest density of plant growth has been expanding into the deeper depth zones.
4) Filamentous algae appeared in 1997.
5) There has been an increased occurrence of floating-leaf and emergent plant species that provide valuable habitat.
6) Since 1988, the maximum rooting depth, number of plant species recorded at the sites, species diversity, species richness and quality of the plant community have all increased.
7) Since 1988, disturbance in the plant community has decreased.

A healthy aquatic plant community plays a vital role within the lake community. Plants provide improved water quality and valuable resources for fish and wildlife. Lakes with a healthy and diverse community of native aquatic plants are more resistant to invasions of non-native species and excessive growth of more tolerant species.

Healthy aquatic plant communities improve water quality in many ways:
Aquatic plants trap nutrients, debris, and pollutants entering a lake;
Aquatic plants absorb and break down some pollutants;
Aquatic plants reduce erosion by stabilizing banks and shorelines, stabilizing bottoms, and reducing wave action;
Aquatic plants remove nutrients that would otherwise be available for algae blooms (Engel 1985).

A balanced, healthy aquatic plant community provides important fishery and wildlife resources. Plants (including algae) start the food chain that supports many levels of aquatic life and, at the same time, produce oxygen needed by animal life. Plants are used as food and cover by a variety of wildlife and as food, cover, and spawning sites by fish (Engel 1985) (Table 15).

Compared to non-vegetated lake bottoms, aquatic plant beds supported larger, more diverse invertebrate populations (Engel 1985). These larger and more diverse invertebrate populations will in turn support larger and more diverse fish populations. Mixed stands of aquatic plants support 3-8 times as many invertebrates and fish as monocultural stands. Diversity creates more microhabitats for the preferences of more species (Engel 1990).

Aquatic plant beds of moderate density support adequate numbers of small fish without restricting the movement of predatory fish (Engel 1990). The coverage of aquatic plants in Round Lake (70% of the littoral zone 50% of the entire lake) is appropriate for supporting a balanced fish community.

Table 15. Wildlife and Fish Uses of Aquatic Plants in Round Lake

Aquatic Plants	Fish	Water Fowl	Song and Shore Birds	Upland Game Birds	Muskrat	Beaver	Deer
<u>Submergent Plants</u>							
Eleocharis acicularis	S	F			F		
Myriophyllum farwellii	C, I*	F(Seeds, Foliage)	F(Seeds)				
Myriophyllum heterophyllum	I*, C	I* F(Seeds, Foliage)					
Myriophyllum sibiricum	F*, I*, S	F(Seeds, Foliage)	F(Seeds)		F		
Myriophyllum tenellum	F						
Najas gracillima	F, C	F*	F(Seeds)				
Nitella sp.		F, I*					
Potamogeton capillaceus		F(Seeds)					
Potamogeton diversifolius		F(Seeds)					
Potamogeton epihydrus	F, I, S*,C	F*(All)			F*	F	F
Potamogeton gramineus	F, I, S*,C	F*(Seeds, Tubers)			F*	F	F
Potamogeton natans	F, I, S*,C	F*(Seeds, Tubers)			F*	F	F
Potamogeton oakesianus	F, C	F*(Seeds)			F*	F	F
Potamogeton pusillus	F, I, S*,C	F*(All)			F*	F	F
Potamogeton robbinsii	F, I, S*,C	F*			F*	F	F
Potamogeton vaseyi		F					

Aquatic Plants	Fish	Water Fowl	Song and Shore Birds	Upland Game Birds	Muskrat	Beaver	Deer
Utricularia gibba	F, C, I*	I*			F		
Utricularia purpurea	F, C						
Vallisneria americana	F*, C, I, S	F*, I	F		F		
Floating-leaf Plants							
Brasenia schreberi	S, I, C	F(Seeds)			F	F	F
Lemna minor	F	F*, I	F	F	F	F	
Nuphar variegata	F,C, I, S	F, I	F		F*	F	F*
Nymphaea odorata	F,I, S, C	F(Seeds)	F		F	F	F
Sparganium fluctuans	C	F (Nutlets)		F		F*	
Emergent Plants							
Carex rostrata	S*	F*	F* (Roots, Sprouts, Seeds)	F* (Roots, Sprouts, Seeds)	F* (Roots, Sprouts)	F	F
Chamaedaphne calyculata				F			F
Eleocharis smallii (palustris)	I	F, C					
Eriocaulon aquaticum	F, S, C	F(leaves), C	F(Seeds)	F (Seeds)	F	F	F
Iris versicolor		F, C	F		F		

Aquatic Plants	Fish	Water Fowl	Song and Shore Birds	Upland Game Birds	Muskrat	Beaver	Deer
Juncus effusus	S	C	C	C	F		
Pontederia cordata	F, I, C	F*(Seeds), C			F		
Sagittaria graminea		F (tubers, seeds)					
Sagittaria latifolia		F, C	F(Seeds), C	F	F	F	
Scirpus cyperinus	F, S, C	F, C	F(Seeds, Tubers), C	F	F	F	F
Scirpus torreyi	F, S, C	F, C	F(Seeds, Tubers), C	F	F	F	F
Scirpus validus	F, C, I	F (Seeds)*, C	F(Seeds, Tubers), C	F (Seeds)	F	F	F
Typha latifolia	I, C, S	F(Entire), C	F(Seeds), C, Nest	Nest	F* (Entire), C*, Lodge	F	

F=Food, I= Shelters Invertbrates, a valuble food source C=Cover, S=Spawning
***=Valuable Resource in this category**

*Current knowledge as to plant use. Other plants may have uses that have not been determined.

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Management Recommendations

Because of the importance of aquatic plants to the lake ecosystem, the high quality and diversity of the plant community in Round Lake and the sensitivity of the aquatic plant community in Round Lake, efforts should continue to protect this resource.

1) Township maintain the slow, no-wake zone. Because Round Lake is very susceptible to impacts from motor boats, a slow-no wake zone, was established in 1996 to protect the aquatic plant communities and the water quality and was marked with buoys. This slow-no-wake zone included the areas that are most susceptible to sediment resuspension and supported the most fragile plant communities. The flocculent, organic sediments in Round Lake are susceptible to resuspension, settle very slowly, and release nutrients as they settle. Since a 50-hp motor can mix and resuspend sediment to a depth of 15 feet (Wagner 1990), approximately 75% of Round Lake (maximum depth of only 18 feet) would be susceptible to impacts by a 50-hp motor. More than 25% of Round Lake is shallow enough to be impacted directly by propellers and hulls. Boating impact studies conducted on Round Lake during the summer of 1994 verified that phosphorus increased and clarity decreased after high boating-use weekends (Asplund 1995). Disturbance within the aquatic plant community has decreased since 1988 and may be due to the protection of this zone. The species that was increasing rapidly, spread by boat fragments (*Myriophyllum heterophyllum)* has decreased since the slow-no-wake zone went into effect.
2) Residents protect and create buffer zones of natural vegetation. Restore natural shoreline in areas of cultivated lawn, along the shoreline to decrease nutrient run-off. One-third of the shoreline on Round Lake is impacted by man-made disturbance and one-fourth is impacted by lawn. Since the watershed of Round Lake is relatively small, nutrient inputs are likely coming from shoreline properties. Starting in the 1970's and 1980's, lakeshore development has been a continuing source of nutrients and sedimentation. Evidence that development on shore has impacted the plant community is two-fold. First, the Average Coefficient of Conservatism and Floristic Quality measurements were higher at the natural sites, indicating that the aquatic plant community at the natural sites is more sensitive to disturbance and closer to an undisturbed condition. Second, the seven Special Concern Species that have the highest sensitivity to disturbance were missing or occurred at a lower frequency at the disturbed sites and the two most tolerant species in Round Lake occurred at a higher frequency at the disturbed shorelines. This difference in the developed and natural shoreline sites impacts the habitat in the lake. The natural shoreline plant community had a greater number of species and a higher Species Richness (species per site). This greater diversity in the plant community will support greater diversity in the fish and wildlife community. The natural shoreline sites had a greater percentage vegetation cover and a greater percentage cover of all types of vegetative structure: submergent, floating-leaf and emergent vegetation. This means more diversity of structure for the habitat with the

emergent and floating-leaf beds being very important components of quality habitat.

3) Residents maintain lakeshore property septic systems. This may be a major source of nutrients into Round Lake, because of the relatively small and protected watershed, nutrient enrichment to Round Lake would primarily come from shoreline properties.
4) Residents, Local Governments and Department maintain protection of the Sensitive Areas designated in 2003. These areas were mapped as the most important areas for fish and wildlife habitat, the best plant beds that are protecting water quality and containing especially sensitive species.
    a) Maintain shoreline vegetation and aquatic vegetation in an undisturbed condition for wildlife habitat and corridor, fish habitat and cover and as a nutrient buffer for water quality protection.
    b) Minimize removal of any shoreline or aquatic vegetation; protect the emergent vegetation as an erosion buffer.
    c) Maintain snag trees to provide wildlife habitat and fallen trees along shoreline for fish and wildlife habitat.
    d) Restrict and limit pier placement, bank grading, recreational floating devices (permit required)
    e) No permit approval for boat ramps, sand blankets, pea gravel beds, dredging, retaining walls, or filling. No alteration of the littoral zone except for improvement of spawning sites.
    f) Restrict bank stabilization to biological methods
    g) Maintain no-wake zone to protect vegetation and protect the sediments from suspension.
    h) Post "Loon Alert" signs.
    i) Restore shrubs and herbaceous plant cover on the old road right-of-way.

5) All lake users protect the aquatic plant community in Round Lake. As a shallow water resource, the plant community is key to preserving the water quality in Round Lake. Shallow lakes in Wisconsin generally exist in one of two states: clear-water, plant-dominated systems or turbid, plant-poor systems. Once a shallow water lake is shifted from a clear-water, plant-dominated system to a turbid, plant-poor system, it is nearly impossible to bring it back to the clear phase. The loss of the plant community would allow wind events to stir up lake sediments and nutrients to be consumed by an increasing algae population. Since Round Lake is dominated by sensitive aquatic plant species, the loss of the plant community could easily happen.
6) Lake residents become involved in the Self-Help Volunteer Lake Monitoring Program. Volunteer data is valuable for tracking changes that may occur in Round Lake.

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